# Computational optical physical unclonable functions

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Abstract

Physical unclonable functions (PUFs) are devices which are easily probed but difficult to predict. Optical PUFs have been discussed within the literature, with traditional optical PUFs typically using spatial light modulators, coherent illumination, and scattering volumes; however, these systems can be large, expensive, and difficult to maintain alignment in practical conditions. We propose and demonstrate a new kind of optical PUF based on computational imaging and compressive sensing to address these challenges with traditional optical PUFs. This work describes the design, simulation, and prototyping of this computational optical PUF (COPUF) that utilizes incoherent polychromatic illumination passing through an additively manufactured refracting optical polymer element. We demonstrate the ability to pass information through a COPUF using a variety of sampling methods, including the use of compressive sensing. The sensitivity of the COPUF system is also explored. We explore non-traditional PUF configurations enabled by the COPUF architecture. The double COPUF system, which employees two serially connected COPUFs, is proposed and analyzed as a means to authenticate and communicate between two entities that have previously agreed to communicate. This configuration enables estimation of a message inversion key without the calculation of individual COPUF inversion keys at any point in the PUF life cycle. Our results show that it is possible to construct inexpensive optical PUFs using computational imaging. This could lead to new uses of PUFs in places where electrical PUFs cannot be utilized effectively, as low cost tags and seals, and potentially as authenticating and communicating devices.

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calibration composability compressed sensing compressive sampling compressive sensing Computational Imaging computational optical physical unclonable functions computational optical PUF COPUF inversion keys copy protection cyber-physical systems Detectors double COPUF system electrical PUF image colour analysis light refraction Optical detectors Optical imaging optical information processing optical polymers optical PUF Optical refraction Optical scattering privacy pubcrawl PUF life cycle refracting optical polymer element resilience Resiliency spatial light modulators