Large-scale discovery of experimental designs in Super-Resolution Microscopy with XLuminA

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ABSTRACT SPACE OF ALL EXPERIMENTAL SETUPS

Contains all the **discrete arrangements** of the optical elements and their variable optical parameters (e.g., phase)

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Experimental blueprint with exceptional and useful property

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ABSTRACT SPACE OF ALL EXPERIMENTAL SETUPS



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Experimental blueprint with exceptional and useful property

Experimental areas and ideas explored by human researchers

Experimental areas to be explored by AI



THE TOPS THICTION. THE SOLUMATES WOLKINGW 15 Fig. 1. We start by feeding the system ndom set of optical parameters, which shape re design on a virtual optical table. The per the virtual experiment's computed by the s nich, leads to detected light offers sintly for e camera), From those simulated outputs, t e functionace for the spot size, is c improve the metric of the cost function, the justs the optical parameters in the initial virt d the cycle is repeated. The whole process is d-forth **Bebased** the simulator and the optimised of the simulator and the sim ing tfersetation tool a convergence 15 observed

XLUMINA's workflow



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FIG. 1. Workflow of XLUMINA, demonstrating the integrated feedback between the AI discovery tool and the optics simulator.

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Large-scale discovery framework

Optics discovery is a discretecontinuous problem: configuring the optical network topology + settings of the optical elements (e.g., phase masks)

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We translate the hybrid discretecontinuous optimization into a purely continuous optimization



Large-scale discovery framework

Computational ansatz:



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Parameters are **continuous** (e.g., phases, distances, beam splitter reflection/transmittance)

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Benchmarks

Rediscovery of **2 foundational experiments** covering different areas in optics:

1. Polarization-based beam shaping as used in STED microscopy [Hell and Wichmann, 1994]

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2. Sharper focus for a radially polarized light beam [Dorn, Quabis and Leuchs, 2004]







Rediscovery through exploration

Ansatz:



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Intensity pro











Rediscovery through exploration: *scaling*



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Rediscovery through exploration: scaling the larger focus



Pure topological discovery for Dorn, Quabis and Leuchs (2003)

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Discovery of a new experimental blueprint

Ansatz:



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Discovery of a new experimental blueprint

Discovered optical layout



0.5 0.0 Lateral position (m)

Discovered phase masks

sSLM in (1)





0.5

1.

Total intensity profile at focal plane

1.0





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Thank you!

The team













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