Free-form Optics Application of Entropic Optimal Transport

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In this work, we address the “freeform optics” inverse problem of designing a reflector surface mapping a prescribed source distribution of light to a prescribed target far-field distribution, for the extended light source.

When the source is a point source, the light distribution has support only on the optics ray directions. In this setting, the inverse problem is well-posed for arbitrary source and target probability distributions. It can be recast as an optimal transport problem and is a classic example of an optimal transport problem with a non-euclidean displacement cost.

We are not aware of any similar mathematical formulation in the extended source case: i.e. the source has an “´etendue” with support in the product space: physical domain-ray directions. We propose to leverage the well-posed variational formulation of the point source problem to build a smooth parameterization of the reflector and the map modeling the reflection. Under this parametrization, we can construct a smooth cost function to optimize for the best solution in this class of reflectors.

Both steps, the parameterization and the cost function, are related to entropic optimal transport distances. We also take advantage of recent progress in the optimization techniques and the efficient implementations of Sinkhorn algorithm to perform a numerical study.