The Geometry of Optical Design

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Abstract: The first photograph was created in 1827 by Joseph Nicephore Niepce. In 1828, William Rowan Hamilton's founding papers on geometric optics began to appear. This seems to be a remarkable coincidence and one would think that the two siblings, photography and geometric optics, would each contribute to the growth of the other. But this never happened. Optical design in the 19th century was largely empirical, and today design is mostly performed by optimizing a cost function which is defined via ray tracing. It is instructive to observer Hamilton's name appears no where in Rudolf Kinglslake's classic 1978 book "Lens Design Fundamentals".

Recent advances in machining, such as 5-axis raster grinding, have now made it possible to make high quality freeform optical surfaces, i.e. surfaces that do not have rotational symmetry. This opens up a whole new realm of design possibilities for illumination and imaging applications, but little theory exists for the design of such surfaces. I will describe methods that I have developed for this problem, based on differential geometry and partial differential equations. For some optical design problems, the surfaces may be modeled as integrals of distributions in Euclidean space. During my lecture prototypes will be available for examination by the audience.