Optimization of Curves Distributions Intersections for a Near to Eye Display Design

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Our team works on an original concept of Near to Eye Display for Augmented Reality applications. This device requires mathematical research to optimize the diffraction phenomenon that forms the images onto the retina. Diffraction is an optical effect strongly related to periodicity and very well formulated by mathematics in particular through Fourier Optics. In order to break the periodicity of our display components we use improved mathematical models of curves. In this model, a first horizontal curve is described by a succession of segments with a unique absolute angle. The other curves are created by the translation of the first curve with a minimal gap equal to a value fixed by physicals constraints. We define vertical curves with the same principle. We use the B-Splines functions to approximate these successions of segments.

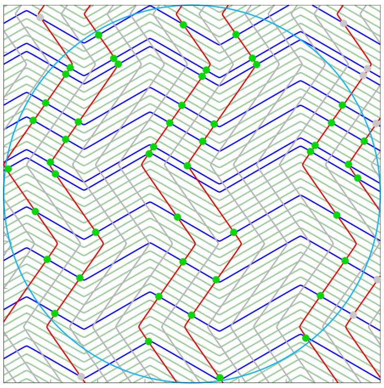

Figure 1: Mathematical model for waveguides and electrodes

In our concept, the horizontals curves represent light waveguides and verticals curves represent electrodes. Our design is based on the use of N_s laser sources and N_e electrical switches. Each source addresses a group of n_w random waveguides and each switch a group of n_e electrodes both drawn randomly without replacement in the curves set. When we turn on a laser source and a switch, the intersection between the corresponding n_w and n_e curves create an Emissive Points Ditribution (EPD). Our patented model of curves intend to define the best EPD surface density as close as possible from a pure random distribution. Our method improves by a factor 3.5 the number of EPD in comparison to an previous model. For our study, we use an iterative method adapted to B-Splines that allows for calculating the intersections between verticals and horizontals curves [1]. Figure 1 shows a graphical representation of the curves, red and blue curves representing activated electrodes and waveguides drawn form the set of periodic curves, respectively.

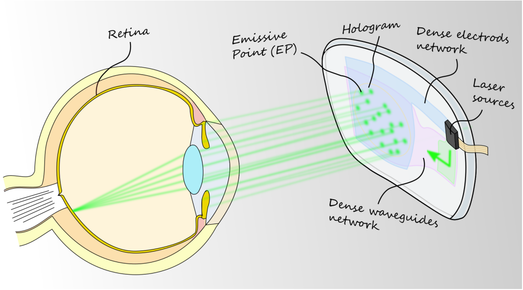

Figure 2: CEA-Leti concept of Near to Eye Display.

Figure 2 shows the concept of NED with a set of holograms, defined by an EPD, that sends light into the eye. The optical signal is diffracted through its propagation in the eye following what we call a self-focusing effect that creates a pixel on the retina [2]. To mathematically simulate the optical diffraction we calculate the Fourier Transform (FT) of the EPD. If the EPD is periodic, the result of the FT is periodic so that the pixel is repeated periodically on the retina without possibility to form an image. Conversely, a random EPD breaks the periodicity and allows isolating a single pixel on the retina. Depending on the surface density of this random EPD the contrast of this single pixel is improved. On the contrary, to form an image with a large number of pixels we need various EPD on the same surface. This leads to a compromise between randomness, surface density and surface diversity that represents one of our research target.

References

[1] K. Mørken et al. Computing intersections of planar spline curves using knot insertion. *Computer Aided Geometric Design*, 26(3):351–366, 2009.

[2] C. Martinez et al. See-through holographic retinal projection display concept. *Optica*, 5(10):1200, 2018.