Theory, simulations, and experiments of laser scanning with rotational Risley prisms

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Rotational Risley prisms are one of the fastest two-dimensional (2D) laser scanning systems. They compete with the most common 2D systems with dual axis galvanometer scanners (GSs), with Micro-Electro-Mechanical Systems (MEMS), or with scanning heads with a fast polygon mirror (PM)with a GS (the latter, for the precise positioning of the scan line) [1]. This presentation briefly reviews such scanning systems, as well as the most common scanning modalities, from raster scanning to Lissajous [] and spiral [], focusing on Risley prisms scanning.

The graphical method that, to the best of our knowledge we have introduced [2], and further on developed for rotational Risley prisms [3] is presented in detail. Its advantages include simplicity (in contrast to existing, rather complicated analytical approaches), as well as precision. For the latter aspect, in contrast to approximate methods, the developed method allows for obtaining (and further on analyze) exact scan patterns produced by such scanners.

This method is presented for all the four possible configurations of a pair of rotational prisms [3]. Their maximum and minimum angular and linear deviations are deduced and analyzed. Their exact scan patterns are simulated graphically by performing ray tracing using a commercially available mechanical design program, CATIA V5R20 (Dassault Systèmes, Paris, France). These patterns are achieved and discussed in a multi-parameter analysis, using all the characteristics of the scanner (angles of the prisms, their indexes of refraction, the distance between them and from the final prism to the scanned place), as well as Marshall's parameters [1], i.e., ratios of the angular velocities and of the individual deviations angles of the prisms considered in the first order approximation. Rules-of-thumb are extracted from the analysis in order to optimize the design of the scanners. Experiments have validated both theory and simulations [2-4].

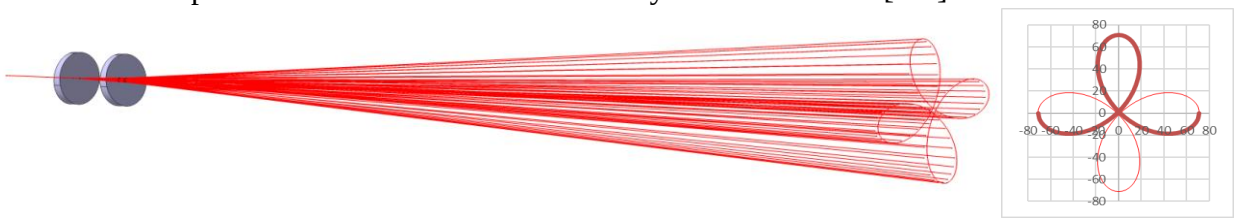

Fig. 1. Scan pattern obtained with the developed graphical method for rotational Risley prisms [4].

Finally, symmetries of the scan patterns are presented as studied in our latest work on this topic [4]. They allowed for extracting repetitive structures within the patterns; they can be utilized to reproduce the entire pattern by rotating the same symmetry structure with certain angles with regard to the determined axes of symmetry. This allow for example for minimizing the time for obtaining high resolution patterns. Future work in this topic, as well as applications conclude the presentation.

[1] G.F. Marshall and G.E. Stutz, Eds., Handbook of optical and laser scanning, second ed. (CRC Press, London 2011).
[2] V.-F. Duma and A. Schitea, Proc. of the Romanian Acad. Series A 19, 53-60 (2018). link
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