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An Optical Processor Specialized on Matrix Operations

A. Mucherino

IRISA, University of Rennes, Rennes, France.

joint work with:

S.B. Hengeveld¹, N. Rubiano da Silva², D.S. Gonçalves³, P.H. Souto Ribeiro³

¹ IRISA, University of Rennes, Rennes, France.

² Federal University of Santa Catarina, Blumenau, SC, Brazil.

³ Federal University of Santa Catarina, Florianópolis, SC, Brazil.

Linear algebra operations are at the core of solution methods for several important problems. One may cite, just to give an example, the GOOGLE PAGE RANK algorithm, whose basic operation consists in a matrix-by-vector multiplication, where the size of the matrix is generally very large. Because of their importance, several works can be found in the scientific literature where researchers have attempted, by using different approaches, to speed-up the computations of linear algebra operations. On the one hand, people have exploited the architecture of computer machines (optimal use of cache memory is a typical example), or modern digital devices such as GPUs, in order to enhance the computations; on the other hand, alternative analog devices have been more recently proposed in an attempt to attain better and better performances.

Our works belong to the latter category and employ an optical processor to perform matrix-by-vector multiplications [3]. This is achieved by using Spatial Light Modulators (SLMs) to encode the data, as well as to perform the computations. The SLMs act on the phase modulation of the horizontal polarization component of the light, in such a way to modify the polarization state when interacting with the corresponding vertical components. By using a Half-Wave Plate (HWP) and a Polarizing Beam Splitter (PBS), the diagonal polarization component is thereafter selected, so that to convert the phase modulation into an amplitude modulation. The result of the computation is finally measured through the intensity distribution in the light beam.

Before proceeding with the realization at hardware level of our optical processor, we have conducted some preliminary experiments on GPUs [2]. We used as a test example the distance geometry problem in dimension 1 [1], which can be solved by computing the sums of the rows or columns of a given matrix (this can be seen as a special case of matrix-by-vector multiplication). When compared against one of the traditional algorithms for distance geometry, we could notice an interesting speed-up, which encourages us to pursue our work. The experiments, however, also pointed out how important is the role of floating-point precision in the representation of the real numbers composing our test problems. This precision issue is likely to have a stronger impact on our optical processor (because it performs computations in an analog fashion), and opens new challenges that we will try to overcome in our future works.

References

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