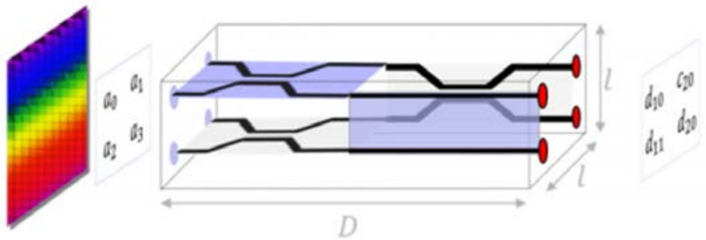
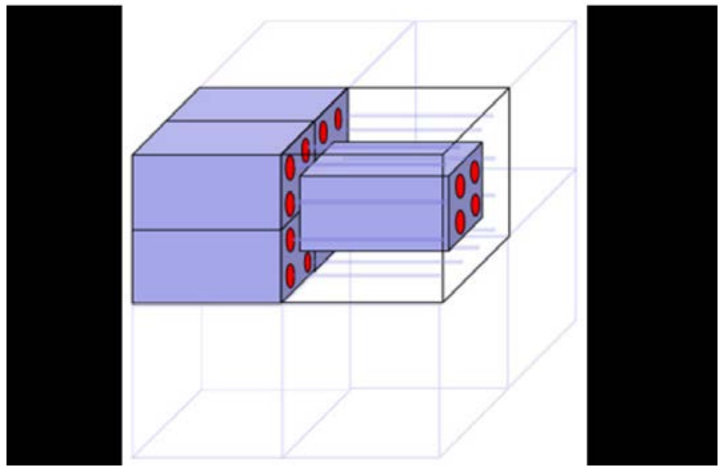
Image Compression Using Optical Transforms

Application of optical processing for video encoding/processing as it is much faster and supports a larger throughput than the electrical processing. Therefore, was defined a general architecture for the acquisition, processing and transmission of video using optical components and was implemented an optical processing module to enable a 2D transform of a video signal.





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Indicators	
Journal Papers	3
Conference Papers	7
Concluded PhD Theses	3
Concluded MSc Theses	3

Two Main Publications

G. Parca, P. Teixeira, A. Teixeira, **All-optical image processing and compression based on Haar wavelet transform**, Applied Optics, Vol. 52, No. 12, April, 2013

G. Parca, P. Teixeira, A. Teixeira, **3D Interferometric Integrated Passive Scheme for All Optical Transform**, International Conference on Transparent Optical Networks (ICTON), Conventry, England, July, 2012

PROJECT WEBPAGE URL
http://www.fct.pt/apoios/projectos/consulta/vglobal_projecto.phtml.en?idProjecto=114838&idElemConcurso=3629

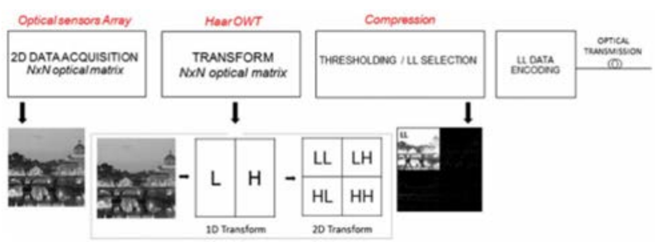

Fig. 1 System building blocks for Haar optical wavelet transform (OWT) based on all-optical processing and compression. 2D transform process schematic describes low-pass (L) and high-pass (H) filtering until sub-band decomposition.

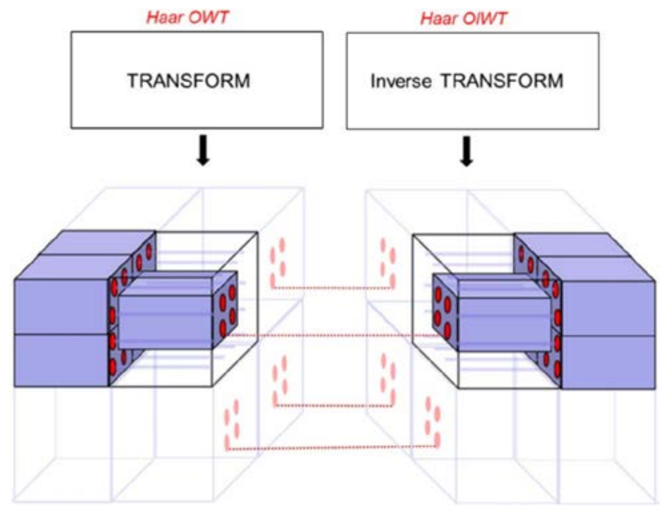

Fig. 2 Integrated passive scheme for Optical Wavelet Transform and Inverse Wavelet transform (WT-IWT); passive compression is accomplished by spatial selection of LL coefficients, delivered through reported connections.

GENERAL MOTIVATION AND OBJECTIVES

Today one can find digital video in a huge number of applications like video conferences, digital television and security system among others. The biggest problem in transmitting digital video is that it has to be compressed so it has the lowest bit rate possible but at the same time the highest possible quality. This implies a trade-off between bit rate and reproduction fidelity but also defines the coding efficiency or rate-distortion performance of the coding system. The idea behind this project was to understand whether it was possible to use optical processing, already a reality in optical communications, in video processing.

The main objectives were to do an all-optical 2D video processing and transmission without any signal conversion to the electrical domain up to the transmission line.

CHALLENGE

Encoding of high-definition video presents nowadays a huge challenge. With the emerging of new formats with even higher computational power requirements, the question is if the processing capacity of the available technology will be able to keep up.

Is it is possible to use optical processing, already a reality in optical communications, in video processing? When achieved this would represent fundamental breakthroughs both in imaging and acquisition.

WORK DESCRIPTION AND ACHIEVEMENTS

The goal of this project was to demonstrate image optical processing. Thus, the first objective was the development/implementation of transforms using only optical components. Our first approach was to use the Discrete Cosine Transform, but other techniques were analyzed and compared to evaluate which was the most suitable for this type of processing. This evaluation was done based on simulation tools, i.e., using MATLAB and Optiwave beam propagation method (BPM). After the most appropriated transform was found, it was implemented using discrete optical components. Following the successful implementation using discrete components, further simulation was done for integrated components. The expected results were transform definition, implementation using discrete optical components, definition of limits and applications.

As stated above, was studied several transform methods. Wavelet Transform (WT) was demonstrated to be the most promising and versatile, being Haar wavelet the less complex method even though the technology needed is not yet commercial. As a result, a design of all-optical system architecture with WT was implemented (figure 1).

Haar Transform (HT) can be implemented using 3 dB asymmetric couplers (also known as Magic-T). In case of 2D data, a single 3D basic module based on a Magic-T network is designed for the implementation of low/high filtering on one dimension. The observed input image transform, compression and reconstruction by means of applying LL (low/low filterering) portion selection on 1st and 2nd HT level transform coefficients and then inverse transforming. (figure 2). Couplers network design and simulation were carried out and the feasibility of Haar Wavelet was demonstrated. Further tests on transform decomposition and reconstruction were performed with and without compression. The method for passive compression was developed and tested in Matlab environment. This method allows a compression ratio of 75% and the image quality after reconstruction was evaluated for several sample image of different sizes in terms of Mean Square Error, Peak signal to Noise Ratio and Quality factor.