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EMBEDDED DISTRIBUTED ARITHMETIC BASED QUATERNIONS MULTIPLIER OF PARAUNITARY FILTER BANK FOR LOSSLESS-TO-LOSSY IMAGE CODING

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Abstract—This paper presents a systematic design of the integer-to-integer invertible quaternionic multiplier based on the block-lifting structure and pipelined embedded processor of the given multiplier using distributed arithmetic (DA) as a block of *M*-band linear phase paraunitary filter banks (LP PUFB) based on the quaternionic algebra (Q-PUFB) for the lossy-to-lossless image coding. A bank Q-PUFB based on the DA block-lifting structure reduces the number of rounding operations and has a regular layout. Since the block-lifting structures with rounding operations can implement the integer-to-integer transform (Int-Q-PUFB).

Keywords: quaternion, filter bank, distributed arithmetic, FPGA, embedded processor

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1. INTRODUCTION

A high-performance filter bank is typically at the heart of every state-of-the-art digital multimedia system [1,2]. Filter banks are adopted in audio, image, and video coding standards such as JPEG, JPEG 2000, JPEG XR, MPEG, and H.264/AVC [2]. To apply filter banks for lossless image coding, they are required to be integer-to-integer transforms [2]. Perfect reconstruction and linear phase, regularity is essential desirable property of filter banks for image coding as it is associated with the smoothness of the related wavelet basis. The ability to design a filter bank is of an extreme importance. It can fully exploit the statistical properties of a particular signal or a class of signals, the goals of the applications and the computational resources available.

As known [3], the most successful philosophy in transform design is to construct highly-complex systems from modular cascades of similar, simple building blocks, each propagating a set of desired transform properties. We have introduced the quaternionic approach to the design and the implementation of four- and eight-channel linear-phase paraunitary filter banks, including those with pairwise-mirror-image symmetric frequency responses [4,5]. The hypercomplex number theory is utilized to derive novel lattice structures in which quaternion multipliers replace Givens (planar) rotations. Recently the block-lifting structure for quaternion-based paraunitary filter banks (Q-PUFB) [6] and biorthogonal filter banks [7] have been proposed. Moreover this block lifting structure is a special class of standard lifting structure. It is a good for lossless–to–lossy (L2L) image coding because it reduces the rounding error by merging many rounding operations [7].

In this paper, a novel approach to the realizing block-lifting factorization of multiplication matrices is presented, which is based on the embedding of the distributed arithmetic (DA) inside the quaternion multiplier block-lifting scheme. The lifting scheme ensures that obtainable approximations of hypercomplex multiplications are perfectly invertible. We have also introduced a systematic design of the integer-to-integer invertible Q-PUFB based on the DA and multiplierless approach (the filter coefficients are sum-of- powers-of-two (SOPO2)). The design problem is formulated as constrained optimization problem, using the reconstruction error, stop-band attenuation and maximum number of ONE bits to represent the coefficient as the objective, and other performance metrics as constraints. Thus, possesses the advantages inherent for such