International Journal of Innovative
Computing, Information and Control
Volume **5**, Number **3**, March **2009**

ICIC International ©2009 ISSN 1349-4198
pp. 689–696

A FAST TWO-DIMENSION 4×4 INVERSE INTEGER TRANSFORM ALGORITHM FOR REAL-TIME H.264 DECODER

Xiuhua Ji[1,2], Caiming Zhang[1,2] and Kai Wang[1]

[1]School of Computer Science and Technology
Shandong Economic University
Jinan 250014, P. R. China
{jixiuhua; zhangcm}@sdie.edu.cn; Kai.Wang@usd.edu

[2]School of Computer Science and Technology
Shandong University
Jinan 250061, P. R. China

Received February 2008; revised July 2008

Abstract. *This paper presents a new fast two-dimensional* 4×4 *(2-D* 4×4*) inverse integer transform algorithm. The algorithm takes advantage of the symmetries of basic images and makes use of the characteristic of the transform data of practical videos. Compared to other fast algorithms, the number of addition and shift operations for the inverse transform can be reduced greatly. Numerical results on several standard video clips indicate that on average, for a* 4×4 *block, the new algorithm needs 12.7838 addition operations and 1.69536 shift operations, which are much less than the other algorithms need. Moreover, the new 2-D algorithm can be parallelized easily.*
Keywords: DCT, Basic image, Image compression, Integer transform

1. **Introduction.** Transform coding has been widely used in image and video coding standards, such as JPEG, MPEG-2, MPEG-4, and H.264. H.264 is the newest video coding standard. It has many new features to achieve significant improvement in coding efficiency and provides more "network friendly" video representation than other existing standards do [1-3]. However, it requires enormous number of computations. This limits the rapid application of H.264 standard.

Just like MPEG-2, H.264 applies the transform coding to the prediction residual. The transform used in h.264, however, is a 4×4 or 8×8 integer transform instead of the 8×8 Discrete Cosine Transform (DCT) that MPEG-2 uses. The integer transform is originated from DCT, but has lower complexity with little performance degradation. It only involves addition and shift operations, and no mismatch exists between the forward and inverse transforms [1,2]. This reduces the complexity significantly compared to DCT. In recent years, many researchers have designed and developed fast algorithms for the integer transforms and integer DCT [4-10]. The most influential fast algorithms for 2-D 4×4 inverse integer transform algorithm at present are in literatures [5,6]. The fast algorithm in [5] treats 2D 4×4 integer transform as a row-column application of the 1-D methods, i.e., the 1-D 4 dots integer transform is separately implemented in each of rows and columns in turn. The algorithm that Fan et al. introduced in [6] is based on sparse factorizations of the matrix. Table 1 shows the comparisons of computational complexity for the fast 2-D 4×4 integer transforms using different algorithms.

In this paper, we propose a novel 2-D fast algorithm for realization of the 4×4 inverse integer transform in H.264. The new fast algorithm is based on basic images of the transform and can exploit the data distribution of transform coefficients. As a result, the