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Jun Tian talks with *ScienceWatch.com* and answers a few questions about this month's Fast Moving Front in the field of Computer Science.

Article: Reversible data embedding using a difference expansion
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SW: Why do you think your paper is highly cited?

Reversible data embedding is a difficult problem. It embeds—or hides—information into a digital content without degrading its perceptual appearance, and has the capability to restore the content to its original, pristine state, bit by bit and exactly. The reversibility is the challenging part. Before our work, there had been a number of exciting breakthroughs in this area, yet the embedding capacity (i.e., the maximal amount of information that could be embedded) was rather limited.

We approached the problem from the different direction of utilizing integer transform, presenting a simple yet effective concept of difference expansion for data embedding, and employed the transform invariants —which is an invariant set of the embedding process—to achieve reversibility. It increased the embedding capacity four-fold (from 0.5 bpp to 2.0 bpp for an 8 bpp grayscale image), and the perceptual quality, after data embedding, was also among the best.

SW: Does it describe a new discovery, methodology, or synthesis of knowledge?

It describes a new method for reversible data embedding. Previously, reversible data embedding methods were mostly compression-based: one selects a region or feature of a digital content, losslessly compresses it, and the space saved from compression will be used for data embedding.

Our method applies an integer transform (for example, integer wavelet transform), and discovers extra storage space in high frequency domains (which are usually small magnitude coefficients). The data embedding is achieved by a simple bit-shift process, which is called a "difference expansion."

SW: Would you summarize the significance of your paper in layman's terms?

Our paper developed a new diagram for reversible data embedding, i.e., integer

transform + difference expansion + location information. The integer transform inherits the advantage of traditional decorrelation transforms, with the additional benefit of reversibility.

The difference expansion technique embeds (and extracts) information by bit shift operation, which gives a large embedding capacity, and maintains the perceptual quality as well. Perceptually, difference expansion is similar to mild sharpening in the mid tone regions.

The location information keeps record of where difference expansion happens, and will be part of the information to be embedded, such that the decoder could extract the embedded information and restore the original content, without referring to any side information.

"Reversible data embedding has a big potential in sensitive imagery, such as military data, medical data, and digital reproduction of fine arts."

SW: How did you become involved in this research and were any particular problems encountered along the way?

Reversible data embedding problems first appeared in late 90s. Inspired by the groundbreaking work of Dr. Chris Honsinger *et al.,* of the Eastman Kodak Company, and also pioneering work from Prof. Jessica Fridrich's group at SUNY Binghamton.

I was excited by this fast-growing area of research and devoted my efforts to investigating new methods. I received tremendous support from my manager, Dr. Steve Decker, to develop high capacity and high perceptual quality reversible data embedding. Lots of failure, and lots of frustrations happened during the development; yet when we finally got there, it was well worth the effort.

SW: Where do you see your research leading in the future?

Reversible data embedding has huge potential uses in sensitive imagery, such as military data, medical data, and digital reproduction of fine arts. In these scenarios, every bit of information is important and should be preserved. With reversible data embedding, for example, metadata could be embedded in the content, which eliminates the requirement of additional storage and is more convenient to manipulate.

Additionally, reversible data embedding is a natural content authentication tool, where the content message authentication code (MAC) could be embedded for self-authentication. Essentially, reversible data embedding provides an additional information channel, which coresides with the digital content.

SW: Do you foresee any social or political implications for your research?

For engineering, especially information communication, yes, I can foresee implications.

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KEYWORDS: DIFFERENCE EXPANSION (DE); LOCATION MAP; REVERSIBLE DATA EMBEDDING; REVERSIBLE INTEGER TRANSFORM.

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