

**DIGITAL WATERMARKING IN 2D AND 3D  
TRANSFORM DOMAINS FOCUSING ON FIDELITY  
AND ROBUSTNESS**

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## ABSTRACT

Digital watermarking technique has been used to deal with issues like copyright protection and authentication to protect legitimate right of the owner and prevent illicit attempt to supersede it by the adversaries. These issues have become a matter of concern due to pervasive usage of digital media at various platforms in recent years. Robust watermarking techniques are usually applied for copyright protection, content authentication and temper localization because it can resist various kinds of manipulations on it. There is a need of developing a truly robust watermark to handle complicated and complex attacks. In this thesis, we focus on geometrically robust watermarking techniques especially invariant domain based technique for digital images. Additionally, we also studied schemes for three dimensional (3D) image representation named Depth Image Based Rendering (DIBR).

We have proposed a robust dynamic block based watermarking technique in 2D domain using Genetic Programming (GP) to achieve imperceptibility and robustness. This technique can embed an imperceptible and robust watermark in images irrespective of the size of the blocks. We present a GP based perceptual shaping function which determines the optimal watermark strength for the selected coefficients using Human Visual System characteristics (HVS) such as luminance sensitivity, and self and neighborhood contrast masking. Our proposed scheme can resist image processing attack, noise attack, geometric attack and cascading attack. Comparison results show that our dynamic block based technique is approximately 5% and 23% more robust than the other two compared techniques.

In addition, we proposed two new invariant domain based watermarking techniques. They are Rotation, Scaling and Translation (RST) invariant domain based on Riesz

Transformation (RT), and fractional calculus based polynomial watermarking domain. We are the first to explore invariant properties of RT, fractional sinc and fractional Heaviside function. The advantage of invariant domain based watermarking techniques is they do not need resynchronization step for the watermark detection. It results in less processing time, and less distortion induced due to resynchronization process.

We also extended watermarking from two dimension (2D) environment to 3D scenario. We have proposed an imperceptible and robust watermarking scheme in Multi-Dimensional Wavelet Transformation (MDWT) domain for the content protection of 3D DIBR. Interval Type-2 Fuzzy Logic System (IT2FLS) is used to determine the weight factor using noise visibility and entropy value to embed watermark imperceptibly. The proposed technique embeds watermark with least distortion in the rendered left and rendered right images for imperceptibility. The experimental results show that the proposed technique is robust against JPEG compression, depth image alteration, Gaussian noise and rotation attacks. Moreover, the bit error rate (BER) of the extracted watermark is nearly negligible.

## **ABSTRAK**

Teknik Watermarking digital telah digunakan untuk menangani isu-isu seperti perlindungan hakcipta dan pengesahan untuk melindungi hak sah pemilik dan mencegah percubaan haram untuk menggantikannya oleh musuh. Isu-isu ini telah menjadi perkara yang membimbangkan disebabkan oleh penggunaan meluas media digital dalam pelbagai platform pada tahun-tahun kebelakangan ini. Teknik Watermarking mantap biasanya digunakan untuk perlindungan hakcipta, pengesahan kandungan dan penyetempatan perubahan kerana ia dapat menahan pelbagai jenis manipulasi ke atasnya. Terdapat keperluan membangunkan watermark yang benar-benar mantap untuk mengendalikan serangan rumit dan kompleks. Sebagai tambahan, satu domain watermarking tak berubah baru diperlukan. Dalam tesis ini, kami memberi tumpuan kepada teknik watermarking geometri mantap terutamanya teknik berasaskan domain tak berubah untuk imej digital. Selain itu, kami juga mengkaji skim perwakilan tiga dimensi (3D) yang dinamakan Rendering Imej Berdasarkan Kedalaman imej (DIBR).

Kami telah mencadangkan satu teknik watermarking multiblok teguh berpangkalan di domain 2D menggunakan Pengaturcaraan Genetik (GP) untuk mengimbangi imperceptibility dan keteguhan. Teknik ini boleh memasukkan satu watermark tak kelihatan dan teguh dalam imej tanpa mengira saiz blok. Kami membentangkan fungsi membentuk persepsi berasaskan GP yang menentukan kekuatan watermarking optimum bagi pekali yang dipilih dengan menggunakan ciri-ciri Sistem Visual Manusia (HVS) seperti sensitiviti lumina dan kejiranan masking kontras diri dan jiran. Skim yang kami cadangkan boleh menentang serangan pemprosesan imej, serangan bunyi, serangan geometri dan serangan melata. Perbandingan keputusan menunjukkan bahawa teknik

berdasarkan multiblock kami adalah lebih kurang 5% dan 23% lebih kukuh daripada dua teknik lain yang dibandingkan.

Selain itu, kami mencadangkan dua teknik watermarking berasaskan domain tak berubah baru. Mereka adalah domain tak berubah terhadap Putaran, Skalaan dan Terjemahan (RST) yang berdasarkan Transformasi Riesz (RT) dan domain berasaskan kalkulus pecahan polinomial. Kami adalah yang pertama dalam meneroka sifat-sifat tak berubah bagi RT, sinc pecahan dan fungsi Heaviside pecahan. Kelebihan teknik watermarking berasaskan domain tak berubah adalah mereka tidak perlu langkah penyerentakan semula untuk mengesan watermark. Ia mengurangkan masa pemrosesan dan mengurangkan gangguan akibat proses penyerentakan semula.

Kami juga melanjutkan watermarking dua dimensi (2D) ke persekitaran senario 3D. Kami telah mencadangkan skim watermarking tak kelihatan dan teguh dalam domain Transformasi Wavelet Multi Dimensi (MDWT) untuk perlindungan kandungan 3D DIBR. Sistem Logik Kabur Selangan Jenis-2 (IT2FLS) digunakan untuk menentukan faktor pemberat dengan menggunakan penglihatan bunyi dan nilai entropi untuk menanamkan watermark secara tak kelihatan. Teknik yang dicadangkan menanamkan watermark dengan penyelewengan kurang dalam imej kiri dan imej kanan untuk imperceptibility. Keputusan eksperimen menunjukkan bahawa teknik yang dicadangkan adalah teguh terhadap pemampatan JPEG, perubahan kedalaman imej, bunyi Gaussian dan serangan putaran. Selain itu, kadar ralat bit (BER) dalam watermark yang diekstrak adalah hampir boleh diabaikan.

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