# A STATISTICAL PERFORMANCE INDICATOR IN SOME IMAGE PROCESSING PROBLEMS

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# ABSTRACT

The ability to compare or relate two digital images may be useful in developing performance evaluation algorithms. This thesis investigates the use of a particular correlation measure, $R_p^2$ developed from the multidimensional unreplicated linear functional relationship (MULFR) model with single slope, as a measure or indicator of performance. This MULFR model is an extended version of the ULFR model introduced by Adcock in 1877. A literature survey was carried out showing that $R_p^2$ has not been used before. The coefficient $R_p^2$ was investigated in its ability to handle the issues of non-perfect reference image, multiple image attributes and combining image local-global information simultaneously. This survey is followed with the maximum likelihood estimation of parameters and a brief discussion of some theoretical properties of $R_p^2$. To investigate robust properties of $R_p^2$, an extensive simulation exercise was then carried out. Promising results, thus far, motivate the use of $R_p^2$ in two image analysis problems; firstly a character recognition problem and secondly a particular data compression problem. In a handwritten Chinese character recognition problem, the $R_p^2$ achieved the highest recognition rates even the pre-processing stage is removed from the recognition system. A substantial reduction of processing time, approximately 40.36% to 75.31%, was achieved using $R_p^2$. In JPEG compression problem, $R_p^2$ is used as a measure of image quality which in turn indicates the performance of the compression method. It is shown that $R_p^2$ performs well and satisfies the monotonicity, accuracy and consistency properties when perfect reference image was used. $R_p^2$ was also shown to perform better than some frequently used similarity measures when imperfect reference image was used.

# ABSTRAK

Keupayaan membanding dua keping imej berdigital merupakan satu unsur penting dalam rekaan algoritma bagi tujuan penilaian pretasi pemprosesan imej. Thesis ini mengkaji penggunaan ukuran korelasi tertentu, $R_p^2$, yang diperolehi daripada model hubungan fungsian linear multidimensi tak replika (MULFR) dengan satu kecendurungan sebagai satu ukuran atau penunjuk prestasi. Model MULFR ini merupakan satu lanjutan dari model ULFR yang diperkenalkan oleh Adcock pada tahun 1877. Satu tinjauan literasi yang dijalankan mendapati bahawa $R_p^2$ belum pernah digunakan sebelum ini. Keupayaan pekali $R_p^2$ menangani tiga isu utama serentak juga disiasat. Isu-isu ini ialah isu imej rujukan yang tidak sempurna, isu kepelbagaian sifat imej dan isu gabungan maklumat imej setempat-sejagat. Tinjauan tersebut disusuli dengan anggaran parameter-parameter dengan kaedah penganggaran kebolehjadian maksimum dan perbincangan ringkas terhadap ciri-ciri $R_p^2$ secara teori. Satu simulasi yang ekstensif juga dijalankan bagi mengkaji ciri-ciri keteguhan $R_p^2$. Hasil simulasi yang memuaskan telah mengalak penggunaan $R_p^2$ dalam dua bidang imej analysis; bidang pertama ialah masalah pengenalpastian huruf dan bidang kedua ialah masalah mampatan data. Dalam masalah pengenalpastian tulisan huruf Cina, pekali $R_p^2$ mencapai kadar pengenalpastian yang paling tinggi walaupun peringkat pra-pemprosesan dikeluarkan dari system pengenalpastian tersebut. Satu pengurangan masa pemprosesan yang banyak, kira-kira 40.36% hingga 75.31% telah dicapai dengan menggunakan $R_p^2$. Dalam masalah mampatan JPEG, $R_p^2$ digunakan sebagai satu ukuran kualiti imej yang selanjutnya dapat menunjukkan prestasi kaedah mampatan tersebut. Didapati bahawa $R_p^2$ mempunyai prestasi yang baik dan memenuhi cirri-ciri ekanada, ketepatan dan konsisten apabila imej rujukan yang sempurna digunakan. Didapati $R_p^2$ juga mempunyai prestasi yang lebih baik berbanding dengan beberapa sukatan keserupaan yang kerap digunakan apabila imej rujukan yang tidak sempurna dipakai.

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# List of Frequently Used Abbreviations

| | |
|---|---|
| CBDD | City block distance with deviation |
| CMF | Compound mahalanobis function |
| CHI2 | Chi-Square measure |
| COD | Coefficient of determination |
| FR | Full reference |
| HCCR | Handwritten Chinese character recognition |
| ISM | Image similarity measure |
| JPEG | Joint photographic experts group |
| MD | Minimum distance |
| ML | Maximum likelihood |
| MOS | Mean opinion score |
| MQDF | Modified quadratic discriminant function |
| MSSIM | Mean structural similarity |
| MULFR | Multidimensional unreplicated linear functional relationship |
| NR | No reference |
| PSNR | Peak signal to noise ratio |
| Rf2/ $R_F^2$ | Coefficient of determination for unreplicated linear functional relationship model |
| RMSE | Root mean square error |
| Rp2/ $R_p^2$ | Coefficient of determination for multidimensional unreplicated linear functional relationship model |
| RR | Reduced reference |
| Rs2/ $R_S^2$ | Coefficient of determination for simple linear regression model |
| SISM | Statistical image similarity measure |
| ULFR | Unreplicated linear functional relationship |

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