**ENTROPY**

|  |
| --- |
| *Definition:* Entropy, in general, is the amount of unpredictability of any random Variable. The entropy of an image is defined as a statistical measure that expresses the randomness of gray levels (colors) and also can be determined as a sum of terms that depend on the probability of occurrence and quantity of gray levels of pixels in the image.  *Brief Overview:* The characteristic of entropy denotes that it is the most important function to analyze an image, when several images are compared that have unequal quantity of gray levels. Basically, we need to know the maximum of the function of entropy under the conditions in which the gray levels have a fixed number. The entropy of a digital image in gray levels, each term of the same is associated to one and only a gray level. In this way, a one-one relation among the terms of entropy is established; that is, gray levels and classes of equivalence. |

*Entropy of an image as explained by Shannon’s equation:*  
Shannon’s Equation is based on the concept that the information obtained from an event is inversely related to its probability of occurrence. Shannon’s concept to define the entropy of an image is by assuming that an image is entirely represented by its gray level histogram only and threshold values for different images with identical histogram.

The behavior of entropy in digital images is done through an iterative algorithm of mean shift filtering. The order of a digital image in gray levels is defined. The behavior of Shannon entropy is analyzed and then compared; taking into account the number of iterations, with the maximum entropy that could be achieved under the same order. The difference of the maximum entropy of order n and the entropy of the image is used to group the iterations, in order to characterize the performance of the algorithm.

**IMAGE REGISTRATION**

Image Registration performs the function of spatially matching two or more images – where one image is taken as a Reference and the relating others to the same space by the geometrical arrangement Sin a coordinate system to indicate important image features such as points, lines, curves, and regions. And then after this alignment brightness values (pixel value) are added to the aligned images through a resampling process. This addition of brightness values, termed as a fusion process, reveals every minute information of the image.

The goal of image registration is to geometrically transform one image so that physical (for medical imaging, physiological) correspondences line up. The most common transformations are rigid, affine, projective, perspective and global. A popular approach to this is to define a similarity measure between the images and performs an optimization over allowed transformations to maximize this measure. Here, we shall consider “intrinsic” image registration methods that are based on voxel or pixel intensities.

**METHODS USED FOR IMAGE REGISTRATION**

1. Point based Method
2. Surface based Method
3. Intensity based Method

**STAGES IN IMAGE REGISTRATION**

1. Preprocessing:   
   It performs Image Smoothening and Deblurring, removal of all unwanted components.
2. Feature extraction, matching and Property Selection:   
   Techniques involved in this stage are extracting points, lines, regions, templates, etc. from images and selecting some crucial information from the images.
3. Correspondence:   
   Determining the correspondence between selected features in images
4. Optimal Transformation Function:   
   From the corresponding feature points determining the transformation parameters
5. Image Resampling:   
   Resampling the sensed image of the geometry of the reference image using the transformation

The most important step here is **Feature Extraction where Voxel based Registration** is used. It is an Intensity based method for Image Registration. It uses voxel intensities to extract important features. This Registration contains Voxels or Pixels which are attributes of an Image which represents the amount of energy. These are an application of Entropy which represents the probability distribution of intensity and the measurement of this over entire image gives the resultant application to Image Registration.

There are states that correspond to the areas in which the individual pixels can occupy. If all such states are equally occupied, the value of entropy that can be produced when each area of the whole image has the same frequency and amounts to maximum. On the other hand, if the image has been distorted, histogram distribution shall be uneven and finally the entropy is low. Moreover, if all of the pixels have the equal value, the entropy of the image is zero.

There is an interactive process called Mutual Information where a similarity measure is defined by images after being aligned, their combined entropies are considered and the areas which are overlapped seem to be more intense compared to other areas. Mutual information is used as a measure of cognizance between two images which is the statistical dependence of corresponding voxels to the images to be registered. Thus we can say that the neighborhood entropy for Concatenated Images is comparatively greater than the individual entropies. This similarity measure, also called normalized spatial mutual information, for 3D brain image registration, is used to show robustness to be much higher than the existing ones. Consequently, it can have greater image degradation and provides more consistent outcomes for intermodal brain image registration.

Thus we can say that calculation of Entropy is the most important process in Image Registration and its use in Mutual Information leads to very accurate and effective Multimodal Image Registrations which helps in pre-operative planning, 3-D Image Registration and Image Guided Surgical Operations.

**REFERENCES**

[1] Kosiński W, Michalak P, Gut P. Robust image registration based on mutual information measure. Journal of Signal and Information Processing. 2012 May 30;3(02):175.

[2] Non-Rigid Multi-Modal Image Registration Using Cross-Cumulative Residual Entropy Image Registration J. Michael Fitzpatrick Vanderbilt University Derek L. G. Hill King’s College London Calvin R. Maurer, Jr. University of Rochester

[3] The Image Registration Techniques for Medical Imaging (MRI-CT) Hiba A. Mohammed Department of Medical Engineering, University of Science and Technology, Omdurman, Sudan Correspondence to: Hiba A. Mohammed , Department of Medical Engineering, University of Science and Technology, Omdurman, Sudan.

[4] Multiple Medical Image Registration Using Entropy of Arithmetic Geometric Mean Divergence Matrix [Bioinformatics and Biomedical Engineering, 2007 ICBBE 2007. The 1st International Conference on](http://ieeexplore.ieee.org/xpl/mostRecentIssue.jsp?punumber=4272484) Bioinformatics and Biomedical Engineering

|  |  |
| --- | --- |
|  | [5] Dietrich NH. *Voxel-based Iterative Registration Method Using Phase Correlations for Three-dimensional Cone-beam Computed Tomography Acquired Images* (Doctoral dissertation, University of Alberta).  [6] Kim J, Fessler JA. Intensity-based image registration using robust correlation coefficients. IEEE transactions on medical imaging. 2004 Nov;23(11):1430-44.  [7] Kahaki SM, Nordin MJ, Ashtari AH, Zahra SJ. Invariant feature matching for image registration application based on new dissimilarity of spatial features. PloS one. 2016 Mar 17;11(3):e0149710 |