**Investigation on Entropy and its role in image registration :**

**Definition of Entropy :-**

Entropy(H) is a statistic that summarizes randomness. It is the measure of information content in an image. The maximum value of entropy can be produced when each gray level of the whole range has the same frequency. If the entropy of the fused image is higher than reference image then it indicates that the fused image contains more information.[1]

**A.)Entropy applied to image registration :-**

The entropy in a image registration is statistical measure which shows the randomness of gray levels (colors). It depends on the probability of occurrence of gray levels of pixels due to which its value will not only depend on pi but as well as on the quantity of gray levels present in the image. This characteristic of entropy reflects that it is a non-trivial function to analyze its values, when several images are compared that do not have the same quantity of gray levels. [1]

**Three Interpretations of Entropy :-**

* Total amount of information an event provides.
* The uncertainty in the outcome of an event
* The dispersion in the probability distribution

Entropy is a measure of histogram dispersion. For instance, a 2-D histogram where each axis is the number of possible greyscale values in each image than each histogram cell is incremented and each time a pair occurs in the pair of images. If the entropy is low we have no uncertainty about the intensity at the point in the image than it is completely homogenous and if entropy is high it means image consists of a large number of intensities. [2]

**Shannon entropy (SE)** is a very useful tool in image analysis whose computation requires the probability density function (pdf) of the corresponding random variable. The entropy of a system as defined by Shannon gives a measure of uncertainty about its actual structure. Shannon’s function is based on the concept that the information gain from an event is inversely related to its probability of occurrence.[2] Its is used to define the entropy of an image assuming that an image is entirely represented by its gray level histogram only. When the images are correctly aligned, the joint histograms have tight clusters, surrounded by large dark regions. T When the images become less well registered there clusters disperse. The tight clusters in the histograms at registration represent a small number of symbols having high probabilities. Surrounding dark regions in the joint histogram represent large numbers of symbols with probability zero. Due to clusters, become there is less intense in high intensity regions of the joint histogram and now dark regions in the histograms become brighter in dark regions. Thus, there is increase in histogram entropy.[3]

**Image registration :-**Image registration is the process in which the most precise match is identified between two images, which may have been taken at the same ordifferent times, by the same or different sensors, from the same or different viewpoints. It is used to find changes in multitemporal images, build 3D models from 2D images, taken from different view points and track objects.[3] **Image registraion is divided into two methods :-**

**1.Area-based and**

**2.Featured based methods.**

**Area-based methods** emphasis is put on the feature matching step rather than the detection of features. Pixel values are used for the matching. **Feature-based methods** also estimate transformation by matching salient features such as lines or points. [4]

**There are four Steps in image registration for both the methods:-**

**1) Feature detection** :- This involves the extraction of features to be used for the matching process. It has features which include edges, contours and lines of intersection.

**2) Feature matching :-**In this section the features detected in the input image and in the reference image is obtained by correspondence between them. Apart from that similarity metrics such as mutual information and feature descriptors are used for this purpose.

**3) Transformation model estimation :-** By matching the corresponding features the mapping functions between the input and reference images are estimated.

**4) Image resampling and transformation** :-According to estimated mapping function the input image is transformed.[4]

**B.)The concept of entropy is used in step feature matching of area-based method with subcategory of mutual information :-**

**Feature Matching :-** The detected features in the reference and sensed images can be matched by means of the image intensity values in their close neighborhoods, the feature spatial distribution, or the feature symbolic description.

**Area-based method:-** It is also called template matching or correlation methods which merge the matching part with feature detection step. These methods deal with the images without attempting to detect salient objects. Windows of predefined size or even entire images are used for the correspondence estimation. It has methods like Correlation method, Fourier method, Mutual information ,Optimization method.

**Now consider Mutual information where entropy is used :-**

Mutual information(MI) is applied in the context of image registration to measure the amount information that one image contains about the other. The maximization of mutual information criterion postulates that mutual information is maximal if images are correctly registered. It has demonstrated to be a very powerful and general similarity metric which can be applied automatically and reliably without prior pre-processing on a huge variety of applications. It is a measure of statistical dependency between two data sets and it is particularly suitable for registration of images from different modalities.[4] In the multimodal registration, entropy-based measures as MI have to be used since the linear dependency is not given. [9] The major difference between algorithms of mutual information is the method by which entropy is estimated. Shannon entropy is used in standard mutual information algorithms. The normalization of mutual information can be understood as a change in the algorithm of mutual information in Shannon entropy, which resolves the registration of images with small regions of overlap.  During the registration of images with different modalities, if images are not converted for their modalities, both the accuracy and speed will be lower in the registration process. In addition, the adaptiveness to local changes is relatively low when mutual information is used for registration. MI produce satisfactory accurate, robust, and reliable results. is a significantly better candidate for a registration criterion. It can be proved that two images are properly matched when their mutual information is maximal. However, the MI-based methods are considered to have a high sensitivity to the implementation decisions. Particularly, the probability distributions’ estimation and the interpreter selection highly impact the accuracy as well as the robustness of the registration process. [5]

**References :-**

1. Viola P, Wells III WM. Alignment by maximization of mutual information. International journal of computer vision. 1997 Sep 1;24(2):137-54.

2. Sabuncu MR. *Entropy-based image registration* (Doctoral dissertation, Princeton University).

3. Amankwah A. Image registration via entropy consideration and data fusion.(2008)

4. Song G, Han J, Zhao Y, Wang Z, Du H. A Review on Medical Image Registration as an Optimization Problem. Current Medical Imaging Reviews. 2017 Aug 1;13(3):274-83.

5. Zitova B, Flusser J. Image registration methods: a survey. Image and vision computing. 2003 Oct 31;21(11):977-1000.