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Overview of image registration

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ABSTRACT

The global demand for low-computation, low-time-consuming, and high-quality image mapping methods has maintained an image registration technique alive in a variety of applications over the last few years. The practise of superimposing pixels or control points from one image on another, namely the target image and reference image, is known as image registration. The emphasis is on different methods of parameter mapping. The reference image and the sensed image are the input images. There are two forms of image registration: area-based and feature-based. Area based works with the image's intensity, while feature based works with the image's feature points or artefacts. In several implementation fields, quick and effective registration strategies are also critical. This paper provides an overview of image registration methods as well as a review.

1. Introduction

The method of overlaying photographs (two or more) of the same scene captured at various times, from different angles, and/or using different sensors is known as image registration (references and sense images) It aligns two images—the reference and sensed images—geometrically. Different imaging conditions have resulted in the current inconsistencies between photographs. Image registration is an important step in all image processing activities that require the final knowledge to be derived from a variety of data sources, such as image fusion, shift identification, and multichannel image reconstruction. In remote sensing (multispectral classification, environmental monitoring, change detection, image mosaicing, weather forecasting, creating super resolution images, integrating information into geographical information systems (GIS)), and medicine (combining CT and NMR data to obtain more complete information about the patient, monitoring tumour growth, and treatment), registration is needed (target localization, automatic quality control)

1.1 IMAGE REGISTRATION

Image registration is described in literature in different ways. It is the mechanism used to align two images. As a basic example, as shown in Fig. 1.1, Image 2 must be rotated to align it with the first image 1 before the fusion process.

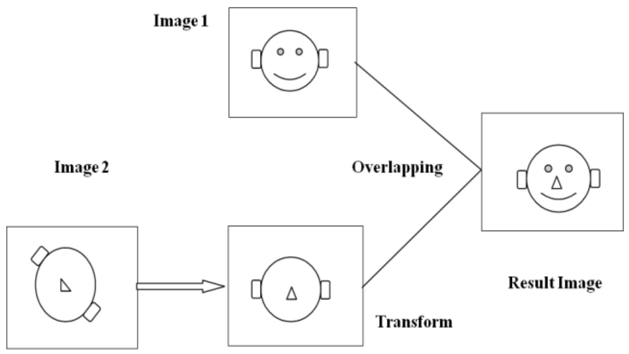

Figure 1.1 Simple concept of image registration

In (Barbara Zitová, 2003), image registration is defined as 'the process of overlaying two or more images of the same scene taken at different times, from different viewpoints, and/or by different sensors'. Before exploring the numerous approaches of image registration, some of the terminologies are introduced here:

- Target (or reference or fixed): the image that is kept unchanged and is used as a basis for the warping.
- Source (or sensed or moving): the image that is geometrically transformed to be aligned with the target image.
- Transformation (or warping): the function used to modify the source towards the target image.

Image registration is defined in various ways in literature. That is the process used to make two images align. As a simple example, as shown in Fig. 1.1, Image 2 needs to be rotated before the fusion process to align it with the first image 1.1.

$I_2(x, y) = g(I_1(f(x, y))$ ………………………………………….(1.1)

where f is a 2-D spatial coordinate transformation, i.e., (x', y') and $f(x, y)$ is 1-D intensity or radiometric transformation. Finding the spatial or geometric transformation is generally the key to any registration problem.

The geometrical transformation parameters of the transformation model are essentially determined by image registration, which can be added to the sensed image to coordinate it with the reference image. Rotation, size and translations are involved in the model of comparability transformation. Rigid transformation requires translations and rotations only while rigid transformations are often permitted to require scaling in the literature. Furthermore an affine transformation may require shearing. This transformation type maps straight lines to straight lines and retains the parallelism between lines. Another class consists of curved transformations that allow straight lines to be mapped to curves. It is also known as transition elastic or deformable. In Fig.1.2, these transformations are shown.

The complexity of the algorithms for image registration depends on the complexity, or degree of freedom, of the geometrical transformation model under consideration. For example, image registration with affine transformation is more difficult than image registration with transformation of similarities as the degree of freedom in previous cases is greater.e.

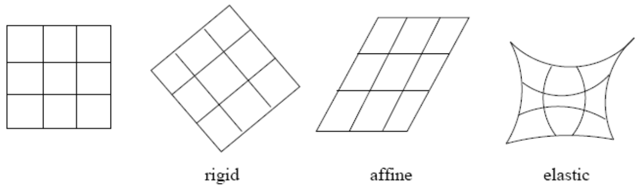

Figure 1.2 Transformation types

Correction to the Geometric Distortion

In general there are two methods that can be used in satellite image datasets to correct different geometric distortions. Systematic correction is one process, since it is systematically focused on certain models. The essence and extent of the causes of geometric distortions are modelled in this system and these models are used by setting the correction formula to correct the geometric errors. Systematic correction is effective where distortions such as the curvature of the planet and the rotation of the earth are well characterised. The second approach relies on the creation of mathematical relationships between the pixel coordinates of an image and the corresponding coordinates of the reference image points. This is known as registration of images. Regardless of any understanding of the image acquisition process or related sensors, these relationships may be formed to correct geometrical errors. Another 'geo-referencing' language is quite a bit like confusing. If the reference image is a map, so image to figure registration is also known as geo-referencing in image registration.

Most of the image registration methods can be best explained by the following four steps:

(1) Feature detection/extraction

Basic and discriminating characteristics, such as point characteristics, are identified either manually or automatically in the first stage of function detection. The point representative named as attribute points, interest points or control points represents these observed features. A descriptor is used in addition to the points to identify the existence of the area surrounded by the points observed, which can be used for further processing.

(2) Feature matching

The mapping or correspondence between the detected functions of both images is found in the feature matching phase. The feature descriptor and similarity function (also known as the calculation of similarity or cost function) are used for that purpose. It is necessary to optimise or minimise to achieve the best matching depending on the existence of the similarity measure.

(3) Transform model estimation

Geometrical transformation parameters such as rotation, translation etc. are estimated based on the correspondence found in the previous step. The complexity of the estimation depends on the number of parameters or the transform model under consideration.

(4) Image re-sampling and transformation

Based on the parameters calculated in the previous step, the sensed image is geometrically transformed to match it with the reference image. In non-integer coordinates, image pixel intensity values are determined by an effective interpolation process such as bilinear, nearest neighbour, bicubic, etc.

These four measures are also seen (Barbara Zitová, 2003) in Fig. 1.3. 3. For the above measures, all the image registration methods differ in terms of how they vary. In addition, if one of the measures is digital, due to the amount of human interaction, it is said to be manual or semi-manual image registration. If no human intervention is needed, automated image registration is required.

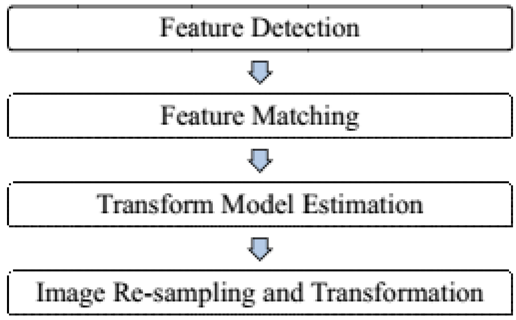

Figure 1.3 Steps for image registration

1.1.1 CLASSIFICATION OF IMAGE REGISTRATION METHODS

The image registration methods may be narrowly categorized as Area Based Methods (ABM) or Feature Based Methods (FBM) (also called spatial or strength or pixel). The Transform Domain Based Approach (TBM) may be called a third type, where any transformation is added to the image and its properties are used to approximate the parameters of geometrical transformation. Under ABM, it can also be taken into account when it first converts the whole image into another area of transformation. This classification is shown in

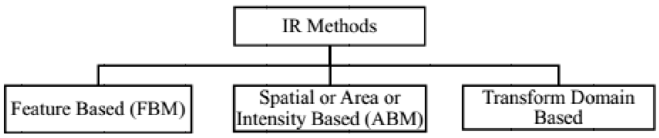

Figure 1.4 Classification of image registration approaches

The strength of each pixel is used as a parameter in ABM, so ABM stresses the matching step of the function and its optimization step rather than its identification, as seen in Fig. Oh. 1.5. There are no features identified in ABM, so the first image registration phase shown in Fig. 1.3 is 1.3 is Omitted, while salient characteristics are first defined in FBM and only those continue in the remaining steps.

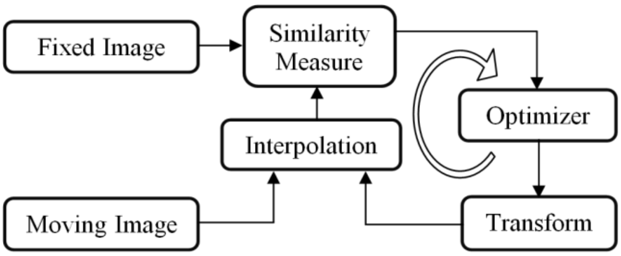

Figure 1.5 Generic flow of ABM for image registration approaches

1.2 IMAGE REGISTRATION FOR REMOTE-SENSING

Remote sensing can be defined as "the process by which information about an object or phenomenon is acquired from a remote place". In our case the objects are on the Earth and the remote place is a satellite or an aircraft. Satellite imaging is referred as "the use of sensors located on space-borne platforms to capture electromagnetic energy that is reflected or emitted from surface of the Earth". In this case the Sun is a source of energy so the sensor is termed as passive source. While in case of active sensors such as radar, they use their own source of energy to capture specific targets.

➢ **Sensor Characteristics**

Different sensors are normally designed for the detection of different types of features in remote sensing, which in turn depends on the specifications or applications. This specifies the sensors' spatial, spectral, radiometric and temporal resolution. The term resolution is "the smallest unit of granularity that can be measured by the sensor". The spatial resolution is "the area on the ground from which reflectance is obtained and integrated to compute the value assigned to each pixel". The spectral resolution is "the bandwidths utilized in the electromagnetic spectrum". The radiometric resolution is defines as "the number of bits which are used to record a given energy corresponding to a given wavelength". The temporal resolution is "the number of observations, defined by the orbit of the satellite and scanning of the sensor".

Most instruments used for remote sensing are multispectral, i.e. multiple bands are used to detect the energy produced or transmitted from the characteristics of the Earth. Detailed detail is given by incorporating panchromatic imagery, which has a higher spatial resolution than that of multispectral imagery in the visible portion of the spectrum. The number of bands in Landsat-4 and 5 grew from four to seven compared to Landsat-1 and 2, incorporating visible and thermal frequency spectrum bands. The Landsat sequence was further expanded with the release of Landsat-7, which provides an additional panchromatic band.

➢ **Importance of Image Registration for Remote Sensing**

In various applications for public gain and/or experimental research, remote sensing is currently moving into practical uses. This has expanded the importance of satellite image database image registration. Natural hazard management, natural resource management, environmental protection, climate change assessment, etc are the applications focused on observing the Earth's surface over time. Nowadays, thanks to numerous missions from several nations, the number of photographs with various characteristics is increasingly available. There is also an increasing need to process various remote sensing images for the extraction and fusion of information. This involves combining newly acquired images with previous images captured with various geometric structures or modalities or with cartographic details. So multi-temporal (captured at various dates), multisource (captured by different sensors), multimode (acquired by different acquisition modalities), or multi-view/stereo images taken from different points of view) may be the satellite images or remote sensing images captured in this manner.

For many factors, image registration of such remote sensing data collected from numerous satellites and airborne instruments has become important. In spatial and radiometric calibration of multi-temporal measurements, image registration plays an important role in obtaining large interconnected datasets for long-term monitoring of different phenomena. In another example, it is important to correctly record multi-sensor and multi-temporal images for identification of changes over time. It has been seen in earlier studies (J. R. G. Townshend, 1992) and (Khorram, 1998) that even a marginal registration error could have a significant effect on the precision of calculations of global change. It is best explained in terms of the Normalized Vegetation Index of Difference (NDVI). When looking at simulated MODIS data at 250-m spatial resolution, a pixel mis-registration error will result in a 50 percent error in the calculation of the pixel.

To the NDVI. Very precise registration, which is very similar to pixel-to-pixel matching, i.e. sub-pixel precision standard, is required for such applications.

It is possible to identify image registration for remote sensing as follows:

- **Multimodal registration**

This enables the complementary information from different sensors. Some of application examples are agriculture and crop forecasting, water urban planning, mineral and oil exploration, cartography, flood monitoring, crop disease control, real estate tax monitoring and detection illegal crop. Here the images to be registered are captured by different sensors. In such application say for example, combinations of remote sensing and Geo Informatics System to help in critical decision making process.

- **Multi-temporal registration**

This may be used to track variations in the data or photographs collected over a period of time or at a particular time from one or more sensors. Cloud removal is another temporary registration application in which photographs of findings over a span of multiple days must be integrated to generate cloud-free files.

- **Multi-view point registration**

This translates data into three-dimensional models from one or more moving platforms interacting together. Examples of those applications are landmark navigation and earth discovery.

- **Multi-template registration**

This is to locate the correspondence within the basis or reference image of the tiny template. It is useful for figure updating and filtering based on content.

Since technology is evolving at such a fast rate these days, today's latest technology may become obsolete tomorrow. As a result, there is a great deal of variety and deterioration in the images that must be recorded. As a result, a single registration system cannot be used to register all types of images. Each approach is tailored to a specific type of image. Figure 1.1 depicts the key processes involved in the registration process as a whole.

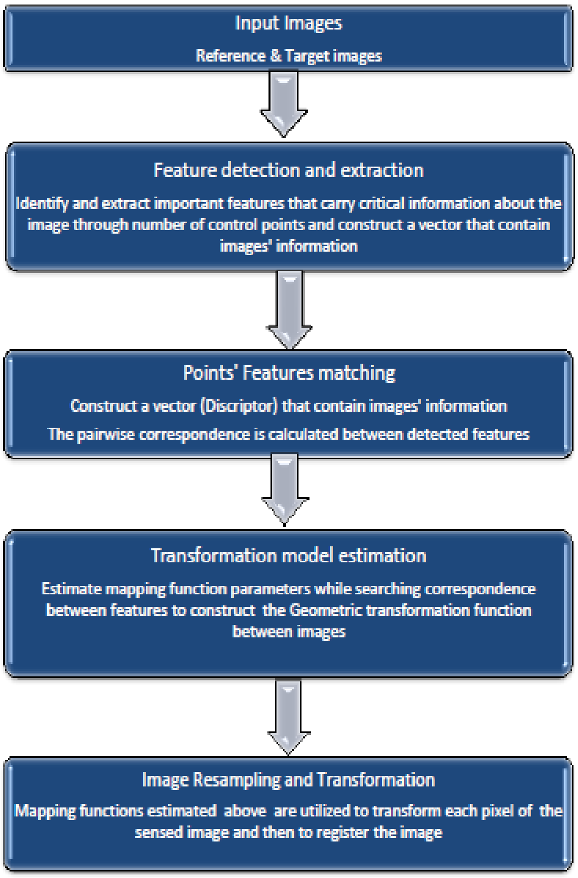

Figure 1.1: Steps involved in generic image registration process

Generally the image registration process consists of the following steps:

1.2.1 DETECTION OF FEATURES

Any part of the image that can be readily recognised and found in both images is referred to as an attribute. This function may take the form of a point, a line, or a corner. Identifying functions can be performed both manually and automatically. Control points are functions that are expressed by their point representation. In general, there are two methods for detecting features: Feature based methods and Area based methods.

a. Feature Based Methods

Point-based approaches are another name for these methods. Using function extraction algorithms, essential features are extracted in this technique. Here, significant regions (fields, lakes), lines (roads, area borders, and rivers), and points (points on intersecting lines, region corners points) are considered features.

It should be guaranteed that such elements are detectable in both images in a specific and effective manner. It is also ensures that features are evenly distributed across the image. Local distortions are tolerated better by them (Zitova and Flusser, 2003). It is expected that features are invariant, which implies that they will stay in their fixed positions over time. For photographs with a lot of intensity differences, feature-based approaches are used. The identification of features is then dependent on the detection of a certain group of features. The groups are grouped together based on the similarities of their characteristics (Saxena and Singh, 2014).

b. Area Based Methods

For template matching, area-based approaches are often used, in which the template's orientation is located in the reference image. As a result, in Area-based methods, the first stage of feature detection is skipped.

1.2.2 FEATURE MATCHING

Once the features in the reference image and the sensed image have been observed, they must be compared using the spatial relationship between them. Image strength values in the vicinity of detected features may also be used to align them.

Control points are detected features in both the reference and sensed images, as we recognise. The pair-wise correspondence between observed features is determined in the feature matching phase using their spatial distribution or separate feature descriptors.

Where there is ambiguous knowledge about the observed features or their neighbourhoods are locally skewed, spatial relations-based approaches are used. The data on the distance between the CPs as well as their spatial distribution is used.

The registration system was created by Goshtasby and Stockman (1985) and is based on the graph matching algorithm. In their article, Stockman et al. (1982) introduced a Clustering method for matching points linked by abstract edges or line segments.

Estimation of function correspondence using their interpretation is a different approach to approaches that rely on spatial relationships. The sensed and reference images' features with the most similar invariant definitions are combined as the matching ones. The type of invariant representation is determined by the feature characteristics and the expected geometric deformation of the images. The minimum distance rule with thresholding is commonly used when searching for the best matched feature pairs in the space of feature descriptors. For improved management of questionable conditions, matching likelihood coefficients (Flusser, 1995) may be an effective and more stable algorithm approach. Guest et al. showed how to choose functionality based on how reliable their potential matches are (Guest et al., 2001).

The picture strength function is the most basic feature definition, restricted to the feature's immediate vicinity (Abdelsayed et al., 1995; Lehmann, 1998). To approximate the function correspondence on these neighbourhoods, the Cross Correlation is used. Ventura et al. (Ventura et al., 1990) used a multi-value logical tree to represent relationships between image features using different descriptors (ellipticity, angle, thinness, etc.). After comparing the multi value logical trees of the reference and sensed images, they discovered the function correspondence. Brivio also used multi-value logical trees in conjunction with moment invariants to balance functions (Brivio et al., 1992).

1.2.3 TRANSFORM MODEL ESTIMATION

The geometric transformation function, also known as the mapping function, is built after the feature correspondence is established. The geometric transformation function (mapping function) maps one image's feature to the positions of similar features in the sensed image. In general, a parametric transformation model is selected based on the capture geometry of the sensed image. Some methods combine this step with the prior, i.e. second step, by estimating mapping function parameters when looking for feature correspondence. The sensed image should be translated so that it can be overlaid on top of the reference image.When using the sensed image transformation in the mapping function design, the correspondence of the CPs from the sensed and reference images is defined, as well as the requirement that the corresponding CP pairs be as similar as possible.The problem is solved by determining the form of mapping function to use and estimating its parameters. The type of mapping function is determined by the assumed geometric deformation of the sensed image, the process of image acquisition, and the necessary registration accuracy (Zitova andFlusser, 2003). Models of mapping functions can be divided into two broad groups based on the volume of image data they handle.

a) Global models

All of the control points are used to approximate only one set of mapping functions, which is then applied to the whole image. The shortest global model is the similarity transform. Rotation, shear, and scaling are the most common transformations. A transformation is a projection from one vector space to another that consists of a linear part, which is represented as a matrix multiplication, and an additive part, which is expressed as an offset or translation.

b) Local Models

Only one series of mapping functions can be used for the whole image in this method of modelling. The image is divided into several bits, each of which is treated as a separate image. The mapping function's parameters are also specified separately for each component.

Goshtas demonstrates the superiority of local registration methods over global registration methods (Goshtasby, 1988; Ehlers and Fogel, 1994; Wiemker et al., 1996; Flusser, 1992). By applying a little difference to the original least square form, the weighted least square and weighted mean methods are used to register images locally (Goshtasby, 1988). The piecewise linear mapping (Goshtasby et al., 1986) and piecewise cubic mapping (Goshtasby, 1987) local approaches, as well as Akima's quintic approach (Weimker et al., 1996), combine CP-based image triangulation with a set of local mapping functions, each valid within one triangle. These methods are part of the interpolating methods community.

1.2.4 IMAGE RE-SAMPLING AND TRANSFORMATION

The sensed image is transformed and then registered using the mapping functions calculated in the previous process. The approximate mapping functions can be used to directly transform each pixel from the sensed signal. Since it is referred to as a forward method technique, its execution is difficult. Because of the discretization, the output image can contain holes and overlaps.

As a result, a technique known as the backward strategy is often used. Using the coordinates of the target pixel (the same coordinate system as the reference image) and the reciprocal of the approximate mapping function, the recorded image data from the sensed image are estimated. The image interpolation takes place on the normal grid in the sensed image. In this way, no holes or overlaps will appear in the final shot.

The picture is normally convolutioned with an interpolation kernel to do the interpolation. Lehman et al. and Parker et al. published survey papers comparing key interpolation methods for 2D image re-sampling, while Grevera and Udupa published 3D image interpolation methods (Lehman et al., 1999; Parker et al., 1983; Grevera and Udupa, 1998).

- **Remote Sensing Automatic Vs Manual Image Registration:**

It is important to identify and compare identical regions in the two images to be documented in the process of image registration. If the user physically executes one or more of these tasks using interactive tools, it is called manual registration of the image. If these tasks are done independently, it is called automated registration of the image. The user selects the distinctive points in the manual image registration from both images, which are usually known also as points of power or points of tie. This control points are matched and matched manually. The parameters of the geometric transformation under consideration are calculated using these corresponding points. Such a manual solution is used by commercially available software such as ENVI, Geomatica, etc. But it's got some pitfalls. It is tedious, laborious, and time intensive, making vast volumes of data prohibitive. For control points, more attention and caution is required in some instances. A collection of durable land features such as some well-known location or any road intersections (Wang and Ellis,) which need to be visited and labelled with the Global Positioning System (GPS) coordinates(2005b). The control points are often referred to as Ground Control Points (GCP) in this situation. For the image registration process, these geo-referenced control points are used.

- **Systematic Correction Vs. Image Registration**

When capturing the image by understanding certain parameters associated with the method, such as the form, direction and shape of the orbit, angle of view, etc the image can be given approximate ground coordinates. Such information is often found in image-related metadata. This form of correction is known as systematic correction, as it is based on a navigation model with several parameters, often referred to as navigation. Systematic correction requires systematic or random errors, since the parameters involved are only valid to a certain extent. To correct these mistakes, precision correction is needed. A precision correction is carried out at the ground base station using the characteristics or material of the image and is referred to as image registration. Systematic correction is based on the standard and registration of images is based on function or content. The accuracy of systemic correction will be within a few pixels, up to a few thousands of pixels, depending on the sensor and how old it is. Within a few pixels, some of the models that use GPS data (E1-Rabbany, 2002) are generally correct. But the optimal precision is up to sub-pixels in certain applications, such as shift detection. Then the appropriate steps to refine the accuracy to the target degree are image registration.

If the metadata is available, the remote sensing images can be routinely corrected. Then, to have the desired precision, image registration is done where only a limited set of geometric transformation parameters must be considered since it is coarsely corrected using systematic correction. But if the images are not corrected routinely,they have to be registered explicitly and no metadata is available. More sets of parameters of geometric transformation need to be considered here.

1.3 **CLASSIFICATION** *CRITERIA* **OF IMAGE REGISTRATION METHODS**

The different discern points can be used to categorise image registration strategies in general. Throughout history, various techniques for image registration have been adopted. Brown classified image registration into four categories based on image acquisition in 1992. The image registration techniques were classified by Barbara Zitova and Jan Flusser (2003) into two categories: field dependent methods and feature based methods. The standards developed by van den Elsen et al. (1993) and Mani & Arivazhagan are used to classify registration methods in this chapter (2013). A significantly enhanced and comprehensive version is provided. Seven simple parameters are used, each of which can be further subdivided. Figure 1.5 depicts the major parameters and principal subdivisions. We'll go through each of the parameters in more depth in the parts that follow.

1.3.1 **DIMENSIONALITY OF REGISTRATION**

The criterion of dimensionality is divided into spatial and time-series dimensions. Picture dimensionality refers to the number of geometrical dimensions of the image space in terms of spatial dimensions. These dimensions are usually three-dimensional in medical settings, but they may also be two-dimensional. The requisite transformation can be computed using either the images' coordinate systems or the physical space and the input image in the registration process. To put it another way, registration could be dependent on a set of corresponding point pairs or a set of corresponding surface pairs (Mani and Arivazhagan, 2013; Beutel, 2000; Hajnal et al., 2001).

I. 2D-to-2D

If the image acquisition process closely influences the geometry of the images, registration can be as simple as a rotation with two orthogonal translations. Additionally, scaling inconsistencies between the physical object and each of the images can need to be corrected. Controlling the geometry of image acquisition is normally a complex process in practice

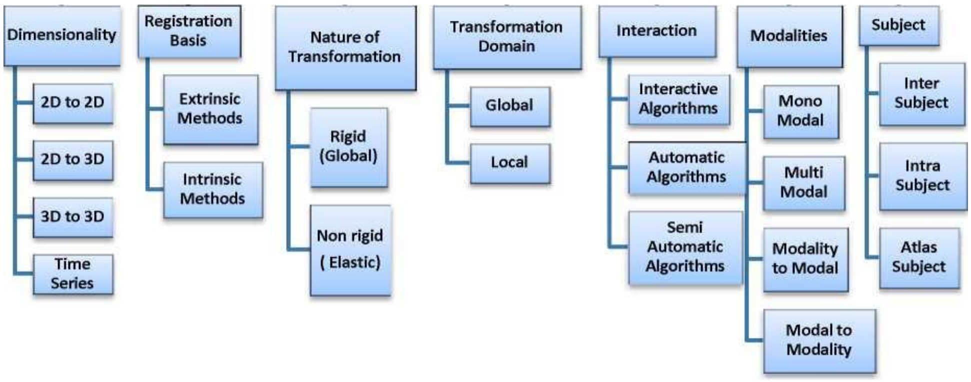

Figure 1.5: Classification Criteria for Image Registration Methods

II. 3D-to-3D

The registration procedure is based on the assumption that the patient's internal anatomy is not skewed or that the spatial arrangements between organs have not changed. To coordinate tomography datasets or a single tomography image to some spatially specified content, 3D-to-3D registration is used. It's worth noting that deciding the size of scanned photos necessitates meticulous scanning system calibration.

III. 2D-to-3D

Where it is necessary to determine the correspondence between 3D volumes and projection images such as X-ray or optical images, the registration procedure is used. Furthermore, they are needed when constructing a 3D volume from one or more slices from tracked B-mode ultrasound, interventional CT, or interventional MR images. It's worth noting that, in comparison to 3D-to-3D registration, 2D-to-2D registration is thought to be less technical, simpler to enforce, and quicker. Furthermore, the most popular and well-developed approach is accurate registration of several 3D volumes of MR and CT images. Furthermore, when a single tomography image is registered to any spatial information source, 3D-to-3D registration provides correct registration performance. Finally, the computational difficulty and speed of implementing 2D-to-3D registration in offline circumstances outside of operations and radiotherapy are not a concern..

IV. Time series:

Medical image registration based on time series is concerned with aligning medical photographs with the same or different modalities over time. Tracking bone development in children (long time interval), monitoring tumour growth (medium interval), postoperative monitoring of healing (short interval), or observing the passage of an inserted bolus through a vessel tree are all examples of how it may be used to track disease progression and evaluate treatment responsiveness (ultra-short interval). As a result, there could be an incentive to improve the precision and accuracy of therapies. To put it another way, registering photographs obtained at varying time intervals aids in a variety of tests, such as tissue perfusion, blood supply, biochemical or physiological cycles, and other complex processes. For example, using this method of registration during radiotherapy aids in quantifying specific bodily motion as well as estimating the treatment reaction of the patient.

1.3.2 NATURE OF REGISTRATION BASIS

Methods in this category are divided into two categories depending on the existence of the registration basis: extrinsic (based on foreign objects inserted into the imaged space) and intrinsic (based on image knowledge provided by the patient) (Hajnal et al., 2001).

I. Extrinsic Registration Methods:

Artificial objects that are distinctly visible are connected to the patient, and they must be correctly observable in all acquired modalities. The following are some examples of widely used attached external objects in medical imaging (Mitchell, 2012): - The stereotactic frame secures the patient's exterior skull table.

- Screw-mounting markers
- Markers smeared across the patient's skin.

These registration methods are characterised by their computational performance and ease of automation. Furthermore, since the transformation parameters are conveniently computed, these approaches do not necessitate complex optimization algorithms (Hajnal et al., 2001). The key disadvantages of extrinsic registration are its prospective nature, which necessitates pre-acquisition planning, and the sometimes intrusive nature of the marker objects.

Non-invasive markers may be used, although they are less effective in most cases. A stereotactic frame (Lunsford, 1988; Vandermeulen, 1991; Lemieux et al., 1994; Lemieux and Jagoe, 1994; Strother et al., 1994; Hemler et al., 1995; Vandermeulen (thesis); Peters et al., 1996) screwed rigidly to the patient's outer skull table is a widely used fiducial item, which until recently provided the strongest " In neurosurgery, certain frames are used for localization and direction. Since neurosurgery is one of the most common applications of registration, using a stereotactic frame in the registration task would not put the patient under any extra intrusive pressure. It is not, however, lawful to instal a frame solely for the purpose of registration. Other intrusive items, such as screw-mounted markers, are sometimes used (Gall and Verhey, 1993; Lam et al., 1993; Maurer et al., 1993; Li et al., 1994; Maurer et al., 1995; Simon et al., 1995; Ellis et al., 1996), but non-invasive labelling instruments are typically used. Markers glued to the skin are the most common (79-85), although larger instruments that can be mounted snugly to the user, such as individualised foam moulds, head holder caps, and dental adapters, have also been used, but they have received little attention in recent literature (Greitz et al., 1980; Laitinen et al., 1985; Schad et al., 1987; Hawkes et al., 1992; Evans et al., 1989). Since extrinsic approaches cannot provide patient-related image details by definition, registration transformations are often limited to be static (translations and rotations only). Furthermore, when used for images with low (spatial) information material, such as EEG or MEG, a measured video image or spatial measurements are often required to provide spatial information on which to base the registration. Extrinsic 3D/3D approaches are largely restricted to brain and orthopaedic (Simon et al., 1995; Ellis et al., 1996) imaging due to the strict transformation restriction and various functional considerations, though markers can also be used in projective (2D) imaging of any body region. In certain cases, non-rigid transforms can be achieved by implanting markers into the cardiac wall, such as in tests of animal heart motion.

II. Intrinsic Registration Methods:

Intrinsic approaches focus solely on image content created by the patient. Registration may be dependent on a small number of known landmarks (landmarks), the alignment of segmented binary structures (segmentation based), most often material surfaces, or directly on measurements calculated from image grey values (voxel property based) (Hajnal et al., 2001).

a. Landmarks based registration methods
b. Segmentation based registration methods
c. Voxel property based registration methods
d. Hybrid based registration methods

a. Landmark Based Registration Methods

Landmarks may be anatomical, i.e., salient and precisely locatable points of the morphology of the observable anatomy, which are normally marked interactively by the individual, or geometrical, i.e., points at the locus of the optimum of any geometric property, such as local curvature extrema, corners, and so on, which are usually automatically localised (Simon et al., 1995). Although the identification of landmark points is technically a segmentation technique, we save classification segmentation-based registration for methods involving the segmentation of higher-order structures, such as curves, surfaces, and volumes. Landmark-based registration is flexible in that it can be applied to any photograph, regardless of the object or subject, at least in principle. Landmark related approaches are mostly used to discover rigid or affine transformations. Theoretically, if the sets of points are large enough, they can be used for more complicated transformations. Anatomical landmarks are often used in conjunction with a very different registration basis (McParland and Kumaradas, 1995; Zubal et al., 1995; Christensen et al., 1996; Evans et al., 1996): approaches that depend on optimization of a non-quasi-convex parameter space are vulnerable to getting trapped in local optima, potentially resulting in a broad mismatch. Such mismatches are unlikely to arise as the search area is constrained by anatomical landmarks. Furthermore, the quest process can be significantly accelerated. The fact that user engagement is normally needed for landmark recognition is a disadvantage. The collection of defined points in landmark based registration is sparse compared to the original image material, allowing for reasonably quick optimization procedures. The average distance (L2 norm) between each landmark and its nearest equivalent (the Procrustean metric) or iterated minimum landmark distances are among the metrics that these algorithms optimise.

The Iterative closest point (ICP) algorithm (Maguire et al., 1991) and derived methods are common for optimising the above metric. Its success can be attributed to its flexibility, which includes the ability to work with point sets, implicitly and specifically defined curves, surfaces, and volumes, as well as its computational speed and ease of use.Other techniques evaluate a variety of possible transition theories, which can be formulated, for example, by aligning three randomly selected points from each point set concerned. Quasi-exhaustive queries, graph matching, and dynamic programming techniques are popular optimization methods here.The used landmarks can be marked geometrically or anatomically by looking at how the voxel amplitude varies with time. The landmarks can also be manually identified. It is important to use the locations' accuracy measurements in the registration process while manually identifying landmarks (Mani and Arivazhagan, 2013).The advantages of such registration bases are that they guarantee the mapping's biological validity. It enables understanding of transformations depending on the underlying anatomy or physiology (Mani and Arivazhagan, 2013).

b. Segmentation Based Registration Methods

Anatomically the same structures (mostly surfaces) are derived from both images to be recorded and used as sole input for the alignment process in segmentation-based registration methods. They can also be deformable model dependent, in which an isolated structure (mostly surfaces and curves) from one image is deformed elastically to match the second image (Hajnal et al., 2001). The static model-based techniques are perhaps the most widely used tools in clinical practise today. The method has remained common since the segmentation task is relatively simple to perform and the computational complexity is limited, and several follow-up papers have been published aimed at automating the segmentation stage, enhancing the optimization efficiency, or otherwise expanding the method.The registration accuracy of segmentation-based methods is constrained by the accuracy of the segmentation step. The methods are usually automated, except for the segmentation process, which is usually done semi-automatically.The optimization criterion for deformable models, on the other hand, is different: it is often locally determined and computed, and the deformation is limited by elastic modelling constraints (imposed by a regularisation term) imposed onto the segmented curve or surface. In the literature, deformable curves are referred to as snakes or active contours, and 3D deformable models are referred to as nets.The deformation process is often carried out in stages, with minor deformations occurring each time. Approaches to deformable models are based on a reference model that must be described in a single image. The prototype is then then deformed to fit a segmented structure in the second image (Davatzikos and Prince, 1994; Sandor and Leahy, 1994; Tom et al., 1994), or the second image is used unsegmented (Gu'eziec, 1993; MacDonald ET AL., 1994). In the latter case, the template's fit criterion may be something like lying on an edge region in the second picture.Deformable models are theoretically very well suited for intersubject and atlas registration, as well as for registration of a blueprint obtained from a patient to a mathematically specified general model of the templated anatomy, as opposed to registration based on derived rigid models, which is primarily suited for intrasubject registration. Deformable models have the disadvantage of requiring a good initial location in order to converge correctly, which is usually achieved by (rigid) preregistration of the images concerned. Another drawback is that if the reference structure varies sufficiently from the reference structure, the spatial deformation of the template will be unpredictable. A common mistake is that the deformable model exactly suits the anatomy, except in one image region where a significant tumour development has arisen. Deformable models are better for finding local curved transformations between images, but not so much for finding rigid or affine transformations (globally). They are normally automatic except for the segmentation process and can be used on almost any anatomical region or modality. It's important to understand that rigidly based approaches are easier to understand than deformable-based methods. The presence of certain regularisation concepts in the cost equation added to the complexity of deformable methods. As a result, for a long time, rigidly based approaches were the most common methods in clinical applications. Furthermore, the approach is common since performing the segmentation procedure is simple and the computational complexity is limited. As a result, several subsequent papers have an automated segmentation phase to improve optimization efficiency or expand the process (Hajnal et al., 2001)

c. Voxel Property Based Registration Methods

The strength variations in each picture are matched using quantitative or statistical principles in these approaches. These techniques assume that the photos at the right registration would be the most comparable. The strength similarity of the input images is calculated based on this assumption to direct transition correction before the maximal similarity is reached. Mean Squared Difference (MSD), Normalized Correlation (NC), Mutual Information (MI), and Normalized Mutual Information (NMI) are common voxel-based similarity indicators (NMI). When the input images in a mono-modal registration have the same grey level configuration, the Sum of Squared Gray Value Differences (SSD) may be used. Cross Correlation (CC) should be used where the same grey level structure does not occur but a linear dependency across the grey levels is at least suspected.

Since there is no linear dependence in multimodal registration, entropy-based methods such as MI must be used. MI and NMI are the most widely used similarity tests due to their ability to provide precise, durable, and consistent performance. However, MI-based approaches are thought to be very sensitive to implementation decisions. The consistency and robustness of the registration procedure was heavily influenced by the calculation of probability distributions and the interpreter variety. According to the assumption of a spatial stationary intensity relationship, intensity-based similarity measurements take place among the corresponding pixels without respect for spatial pixels' dependence. When two images must be recorded, this results in the steps failing to prevent distortion corruption with spatially varying severity (Mani and Arivazhagan, 2013).

d. Hybrid Based Registration Methods

These approaches incorporate geometric and strength features in order to provide more reliable methods for establishing more precise correspondences in complex registration problems.

2. LITERATURE REVIEWS

In Dong Li et. al.(2018), the required function and parameter retrieval algorithm for feature-based registration of synthetic aperture radar (SAR) images is investigated. Tie circles, Harris corners, SIFT, and SURF are some of the most widely used functions that are thoroughly tested. On parameters such as geometrical invariance of function and descriptor, extraction and matching speed, localization precision, and robustness to decorrelation and speckling, SURF outperforms others. In terms of the possible relationship between the Fast-Hessian detector and the refined Lee filter, the processing result shows that SURF has a lot of versatility when it comes to SAR speckles. Furthermore, applying Fast-

Hessian to oversampled images while maintaining the same sampling stage improves registration accuracy to subpixel (i.e., 1 pixel). The commonly used random sample consensus (RANSAC) for parameter extraction is ineffective because it can trap in local occlusion, resulting in unknown estimate. The extended swift least trimmed squares (EF-LTS) algorithm is proposed, which is more robust and performs better on average than RANSAC. For SAR image registration, it is therefore recommended that SURF features be fitted with EF-LTS. This scheme's excellent efficiency is shown on both InSAR and MiniSAR image pairs..

In Chelbi & Mekhmoukh(2018), aligning images is expected in many research areas, including medical image analysis, pattern recognition, computer vision, and remote sensed data processing. This essay discusses and contrasts two approaches for registering photographs. The Fourier Merlin transform is used in the first step, which is dependent on the phase similarity of the two images in the Log-polar domain. It does, however, suffer from non-uniform sampling, which makes it unsuitable for applications where image detail is lost, lowering registration accuracy. The second approach is to extract the rotation angle using the Radon transform properties. Experiments demonstrate that the suggested approach can accurately detect the angle of rotation for a variety of image types without the use of SAR complex images.

Li Chen et al. (2015) presented a new retinal image segmentation and registration approaches. The contribution of this paper is two-fold. First, the conventional vesseltracking methods use local sequential searching, which can be easily trapped by local intensity discontinuity or vessel rupture. The proposed method uses global graph- based decision that can segment the topological vascular tree with 1-pixel width and fully connection from retinal images. Staring from initial multi-scale ridge segmentation, the disconnected vessels are retrospectively connected and then spurious ridges are removed using a shortest path algorithm on a specially defined graph. The hypothesis testing is defined in terms of probability of pixel belong to foreground and background, which enables that the false detections could be removed. Second, the conventional point-matching methods largely depend on the branching angles of single bifurcation point. The feature correspondence across two images may not be unique due to the similar angle values. In view of this, structurematching registration is favored. The bifurcation structure is composed of a master bifurcation point and its three connected neighboring pixels or vessel segments. The characteristic vector of each bifurcation structure consists of the normalized branching angle and length, which is fairly robust to be against translation, rotation, scaling and even modest distortion. The experimental results are presented to demonstrate the superior performance of the proposed approach (Chen et al., 2015).

Later, Kun Sun et al. proposed a Feature Guided Biased Gaussian Mixture Model (FGBG) for image matching in 2015. They presented the matching task as a Maximum a Posteriori (MAP) problem by considering one point set as the centroid of a Gaussian Mixture Model (GMM) and the other point set as the data. A Thin Plate Spline (TPS) transformation between the two point sets is learnt so that the GMM can best fit the data. The main contribution is to assign each Gaussian mixture component a different weight. This is where this model differs from the traditional Self Governed Balanced Gaussian Mixture Model (SGBG), whose Gaussian mixture components have equal coefficients. The new weight is defined as a value related to feature similarity, which can be computed by simply decomposing a distance matrix in the feature space. In this way, both feature similarity and spatial arrangement are considered. The feature descriptor is introduced as a reasonable prior to guide the matching and the spatial transformation offers a global constraint so that local ambiguity can be alleviated. It is shown that the proposed FGBG algorithm is robust to outliers, deformation and rotation (Sun et al., 2015).

In Baharul & Jahangir(2013), IR (Image Registration) is an essential procedure in image processing systems. It is the method of aligning two or more images captured at various times, from different sensors, or from different viewpoints into one coordinate system. It has a wide range of uses, including medical imaging and remote sensing. The key goal of this paper is to include a thorough analysis of the current literature on image registration systems and to introduce a new feature-based IR methodology that uses the edges of photographs. For registration, we used edges as a function of the photographs. It would be a valuable resource for researchers working on feature-based image registration, regardless of the application.

To achieve better registration between two or more images which have difference in shifting, scaling and rotation was also developed in 2010 by Lin and Zhao. It is an automated image registration method based on affine transformation model. Corner detection is used to solve the shifting transformation. At first, the corner features were extracted by Harris operator and then image edge detection was conducted by the Canny operator (Canny, 1986). This algorithm is very simple, has low computational complexity and is more reliable (Hui &weichang, 2010; Canny, 1986). Line is also considered as one of the featutre points to provide information about image. Ke Wang et al. (2013) proposed a Point-Line Duality (PLD), i.e. a line in the image (x-y) space corresponds to a point in the dual (*6-p*) space, based line matching method for image registration in the paper,. First, edge points are detected in a template image and a target image. The edge points are linked and segmented into chains. The chains are fitted to lines and the lines are mapped to dual points in the dual space. To improve stability and efficiency, a point merging algorithm is proposed to deal with the fragmentary line segments that should belong to a single line. As a result, a line matching problem is converted to a point pattern matching problem. Finally, a point pattern matching algorithm is proposed to determine registration parameters and to determine matched line pairs. Experimental results demonstrate that the proposed method is effective for images under rigid body transformation, occlusion and illumination change (Wang et al., 2013). Segmentation of images plays an important role to extract features in case of image registration. Hassan Mahmoud and Francesco Masulli presents an approach to medical image registration using a segmentation step based on Fuzzy C-Means (FCM) clustering and the Scale Invariant Feature Transform (SIFT) for matching keypoints in segmented regions. To obtain robust segmentation, FCM is applied on feature vectors composed by local information invariant to image scaling and rotation and to change in illumination. SIFT is then applied to corresponding regions in reference and target images, after the application of an alpha-cut. The proposed registration method is more robust to noise artifacts than standard SIFT. The paper shows also a method for FCM clustering speeding-up based on a dynamic pyramid approach using low resolution images of increasing size (Mahmoud et al., 2013). However, proper identification and extraction of image features turns out to be a challenging task. Generally speaking, a good image feature extraction method should have the following two properties: (i) The identified image features should provide us proper information to approximate the geometric matching transformation accurately and (ii) they should be easy to identify by a computer algorithm so that the entire feature extraction procedure is computer automatic. Together with the widely used thin plate spline (TPS) geometric transformation model is shown by Peihua and Chen (Qiu and Xing, 2013).

Karthik Krish et al. (2010) introduced a new feature-based image registration technique which registers images by finding rotation and scale-invariant features and matching them using a novel feature matching algorithm based on an evidence accumulation process reminiscent of the generalized Hough transform. Once feature correspondence has been established, the transformation parameters are then estimated using non-linear least squares (NLLS) and the standard RANSAC (random sample consensus) algorithm. The technique is evaluated under similarity transforms - translation, rotation and scale (zoom) and also under illumination changes (Krish et al., 2010). It was further extended by Mahesh and Subramanyam (2012), who showed Scale Invariant Feature Transform (SIFT) algorithm for satellite images taken from Google earth. It detects features that are invariant to rotation, scaling, translation and illumination. Their algorithm finds scale invariant key points and Euclidean distance initial match to combine with Random Sampling Consensus (RANSAC) to achieve feature matching. The best candidate match for each key point is determined by its nearest Euclidean distance feature points from other images. They got very less root mean square error between the matched points after transformation (Mahesh and Subramanyam, 2012). Image registration of images acquired by different viewpoints is another challenge in image analysis. In 2010, Park and Martin proposed a new method that is based on affine transformation. This technique determines the transformation parameters which map pixel from one image to another and enables the comparison of images acquired from different viewpoints. Misalignment of images can be corrected using these parameters. In this method affine based on Fourier slice analysis and Fourier spectral alignment. It shows the performance parameter in terms of speed and accuracy. This method requires fast computation and high reliability. The advantage of the proposed method is the capability to estimate the full affine transformation and reflection symmetry accurately (Heechan and Graham , 2010). But images having different scales were not considered. Then, Gillon and Agathoklis (2010) proposed a new technique based on Mexican-hat wavelet for feature extraction. In this paper, magnitude of Zernike moments for finding the correspondence between points in the two images and iterative weighted least square minimization algorithm to provide the transformation parameter are used. This method deals with the images having different scales and affine distortions (Steven and Pan, 2010).

Lee Cooper et al. (2009) proposed a method for the automatic non-rigid registration of histological section images with different stain types. Correlating information from adjacent slides with different stain types requires establishing spatial correspondences between the digitized section pair through a precise non-rigid image registration. However, the dissimilar appearances of the different stain types challenge existing registration methods. This method is based on matching high level features that are representative of small anatomical structures. This choice of feature provides a rich matching environment, but also results in a high mismatch probability. Matching confidence is increased by establishing local groups of coherent features through geometric reasoning. The proposed method is validated on a set of FL images representing different disease stages. Statistical analysis demonstrates that given a proper feature set the accuracy of automatic registration is comparable to manual registration (Cooper et al., 2009). One of the major problem is to have invariant features for good image registration.

Zitova and Flusser (2003) classified image registration as area based and feature based methods. Area-based method is preferred, when the images do not have much detail information and the gray level provided are to be distinctive rather than local objects, shapes and structures. Li et al. (1995) proposed an approach to register images from multiple sensors by a contour based approach. The success of their method depends on the assumption that the similar structures of images must be preserved well. Therefore their method is efficient only when contour information is well preserved.

David et al. suggested solution for the fundamental problem of point matching in 1999. Given the two sets of points, find the affine transformation which transforms sensed image points so that its distance from the other reference image points is minimized. They measure distances using the partial Hausdorff distance. Point matching can be a computationally intensive task so they present two algorithms for point matching problem with an attempt to reduce computational complexity and still providing a good match. First algorithm is based on a branch and bound approach which show that by varying the approximation error bounds, it is possible to achieve a tradeoff between the quality of the match and the time required for the algorithm. Second method uses Monte Carlo method for accelerating the search process used in first algorithm (David et al., 1999).

3. APPLICATIONS OF IMAGE REGISTRATION

Medicinal Image Registration (for details of an organism captured at various points in time, for example, different exploration or cyst observing) often additionally includes elastic (also known as non-rigid) enrollment to conform to topic distortion (because of breathing, anatomical changes, et cetera). Non-rigid registration of therapeutic images may also be used to enlist a quiet's data to an anatomical map book, such as the Talairach chart book for neuro imaging. It is used in astrophotography to alter images that have been absorbed by the room. The PC makes adjustments on one picture to make substantial elements adjust to a second picture using control focuses (naturally or physically entered). Image registration is an essential part of the overall image development process. There are a variety of techniques that can be implemented gradually and run on embedded devices such as cameras and camera-telephones.

An indeterminate picture enrollment may mean that a response could be a few kilometres from ground truth in remote detecting applications where an advanced picture pixel may refer to a few kilometres of spatial separation (for example, NASA's LANDSAT symbolism).

Remote sensing, natural observation, difference identification, picture mosaicing, climate determining, super-determination pictures, incorporating data into geographic data frameworks (GIS), in drug (consolidating information from various techniques d. g. PC tomography and attractive reverberation visualising known as (MRI), to acquire further information

It's used in computer vision, therapeutic imagery, organic imaging and mind mapping, military programmed target recognition, and capturing and analysing satellite images and data.

It is needed in remote sensing (multispectral grouping, natural observation, change discovery, picture mosaicing, climate determining, making superdetermination pictures, coordinating data through geographic data frameworks (GIS)), in solution and NMR data to obtain accurate finish data about the patient, cyst development, cure confirmation, and examination of the quiet's information (target restriction, programmed quality control).

4. CONCLUSION

Image registration is a technique for mapping the reference image to the sensed image. The four simple image registration measures have a significant effect on a variety of applications. Image registration algorithms have a wide range of approaches for image mapping in order to produce the final image. Image fusion of multiple images, shift identification for a specific region, super-resolution imaging for successful performance, and building image information systems are only a few of the applications. We will find the best results in all unregulated conditions using the above-mentioned literature and recent advances in image registration techniques. The methods used are determined by the material, object characteristics, and viewing conditions. The methods discussed can be used to solve a wide range of problems involving features such as corners, margins, and other features that are described by control points. The majority of the tactics have been examined, along with their outcomes. Mutual information-based registration is fully automated and data-independent. The Mexican hat and the radon transform are used to align pictures with a high degree of rotation and size. Harris corner detection is a rotationally invariant function matching technique that is better at finding intersecting points. SIFT is invariant to affine, size, rotation, and generates a large variety of functions, as well as being the most efficient in noisy environments. The SURF algorithm increases image accuracy by increasing the number of matching points. For a faster execution time, the FAST algorithm is rotation and scale invariant. As a result of the above research, we can infer that the SIFT algorithm is well suited for feature detection while sacrificing little in terms of running time. This review aids in the improvement, compactness, and efficiency of image registration techniques, as well as the reduction of image registration errors.

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