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A METHODICAL WAY OF IMAGE REGISTRATION IN DIGITAL IMAGE PROCESSING

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Abstract— **Image registration is the fundamental task used to match two or more partially overlapping images taken, for example, at different times,from different sensors, or from different viewpoints and stitch these images into one panoramic image comprising the whole scene. It is afundamental image processing technique and is very useful in integrating information from different sensors, finding changes in images taken at different times, inferring three-dimensional information from stereo images, and recognizing model-based objects.**

This paper overviews the theoretical aspects of an image registration problem. The purpose of this paper is to present a survey of image registration techniques. This technique of image registration aligns two images geometrically. These two images are reference image and sensed image. The ultimate purpose of digital image filtering is to support the visual identification of certain features expressed by characteristic shapes and patterns. Numerous recipes, algorithms and ready made programs exist nowadays that predominantly have in common that users have to set certain parameters. Particularly if processing is fast and shows results rather immediately, the choice of parameters may be guided by making the image ―looking nice‖. However, in practical situations most users are not in a mood to ―play around‖ with a displayed image, particularly if they are in a stressy situation as it may encountered in security applications. The requirements for the application of digital image processing under such circumstances will be discussed with an example of automaticfiltering without manual parameter settings that even entails the advantage of delivering unbiased results.

Keywords: Digital Image processing, digital filter, filter parameter, unbiased image processing, security applications.

1. Introduction

Image registration is establishment of correspondence between images of the same scene. Many image processing applications like remote sensing for change detection, estimation of wind speed and direction for weather forecasting, fusion of medical images like PET-MRI, CTPET etc need image registration. Image registration is a process of aligning two images acquired by same/different sensors, at different times or from different viewpoint.

To register images, we need to determine geometric transformation that aligns images with respect to the reference image. The most common transformations are rigid, affine, projective, perspective and global. A variety of approaches have been published on this topic. Over the years, a large range of techniques has been developed for various types of problems. All these techniques have been independently studied for different applications. This paper organizes this research by establishing the relationship between the variations in the images and the type of registration techniques which can most appropriately be applied. All registration techniques explained in paper are useful for understanding the merits and relationships between the wide variety of existing techniques and for supporting in the selection of the most appropriate technique for a particular problem.

Image processing methods, which are possibly able to visualize objects inside the human body, are of special interest. Advances in computer science have led to reliable and efficient image processing methods useful in medical diagnosis, treatment planning and medical research. In clinical diagnosis using medical images, integration of useful data obtained from separate images is often desired. The images need to be geometrically aligned for better observation. This procedure of mapping points from one image to corresponding points in another image is called Image Registration. It is a spatial transform. The reference and the referred image could be different because were taken

- At different times
- Using different devices like MRI, CT, PET, SPECT etc (multi modal).
- From different angles in order to have 2D or 3D perspective (multi temporal).

Image registration finds its applications in various fields like remote sensing (multispectral classification), environmental monitoring, change detection, image mosaicing, weather forecasting, creating super-resolution images, integrating information into geographic information systems (GIS)), in

medicine (combining data from different modalities e.g. computer tomography (CT) and magnetic resonance imaging (MRI), to obtain more complete information about the patient, monitoring tumor growth (Figure 1), treatment verification, comparison of the patient's data with anatomical atlases ,in cartography (map updating) and in computer vision (target localization, automatic quality control).

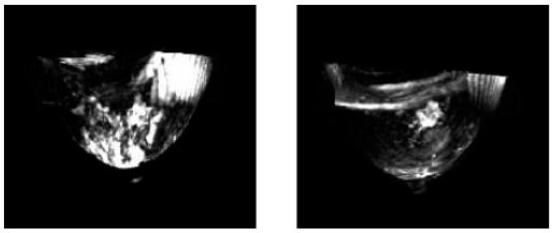


Fig. 1 : Application of Image Registration in MR Mammography

Figure 1 shows a maximum intensity projection of contrast controlled MR mammography a) without registration b) with registration. It demonstrates superior performance in identification of cancerous lesions with the use of registration

2. Classification

P. A. Van Den Elsen, E. J. D. Pol and M. A. Viergever, had given classification of Image registration way back in 1993 [4]. Maintz later in his survey paper [5] has given a more detailed and augmented version of classification based on nine basic criteria. Leszek Chmielewski, Dorota Kozinska [9] have summarized classifications given by earlier papers [4],[6],[7],[8] The classification is based on following features. Wan Rui, Prof.Li Minglu [9] have also has mentioned similar classification.

Dimensionality: 2D/2D, 2D/3D, 3D/3D Image registrations are possible. Sometimes time could be the fourth dimension.

Domain of transformation: It could be global or local depending on whether the whole image or its part is to eregistered. A transformation is called global if it applies to the entire image and local otherwise. Optimization Procedure : The parameters that make up the registration transformation can either be computed directly from the available data, or determined by finding an optimum of some function defined on the parameter space.

Modalities Involved: Four classes of registration tasks can be recognized based on the modalities that are involved. In mono model applications, the images to be registered belong to the same modality, as opposed to multimodal registration tasks, where the images to be registered stem from two different modalities. In modality to model and patient to modality registration only one image is involved and the other modality is either a model or the patient himself.

Subject: In intra-subject registration, all images involved are from the same patient. If the registration process involves images of different patients (or a patient and a model), it is inter-subject registration. If one image involved is from a patient, and the other image is created from an image information database obtained using imaging of many subjects, then it is an atlas registration.

Object Registration Methods : These can also be classified according to the body parts that are involved, e.g. head, thorax.

Interaction: Three levels of interaction can be recognized. Automatic, where the user only supplies the algorithm with the image data and possibly information on the image acquisition. Interactive, where the user does the registration himself, assisted by software supplying a visual or numerical impression of the current transformation, and possibly an initial transformation guess. Semi-automatic, where the interaction is required to either initialize the algorithm, e.g., by segmenting the data, or steer the algorithm, e.g., by rejecting or accepting suggested registration hypotheses.

Nature of Registration Basis: Registration can be images based or non-image based. The latter usually necessitates the scanners to be brought in to the same physical location,and the assumption that the patient remains motionless between both acquisitions. Image based registration can be divided into extrinsic and intrinsic methods. Extrinsicmethods rely on artificial objects attached to the patient, objects which are designed to be well visible and accurately detectable in all of the pertinent modalities. Intrinsicmethods rely on image content only. Registration can be based on a limited set of identified salient points (landmarks), on the alignment of segmented binary structures (segmentation based), mostly object surfaces, or directly onto measures computed from the image grey values (voxel property based).

Nature of Transformation: The transformation applied to register the images can be categorized according to the degrees of freedom. A rigid transformation can be defined as one that includes only translations and rotations. If a rigid transformation is allowed to include scaling and shearing, it is referred to as affine. This type of transformation maps straight lines to straight lines and preserves the parallelism between lines. The perspective transformation differs from the affine transformation in the sense that the parallelism of lines need not be preserved. The fourth class consists of elastic transformations, whichallow the mapping of straight lines to curves, and is called curved transformation.

Type of transformation: The transformation could be rigid, affine, projective or nonlinear.

Tightness of feature coupling: The transformation can be interpolating (features of the objects in one image are exactly transferred into features in the other image) or approximating.

Measure of registration Quality: Various measures are applied depending on the data features or data itself.

Method of parameter determination: The parameters of the transformation can be found out using direct or search oriented methods.

Subject of registration: If the two images contain the same subject it is intra subject registration. If the subject in the two images differs it is intersubject registration.

Type of data: It can be raw data, features extracted from data or introduced markers in data.

Source of features: Features explicitly present in the data are called intrinsic features where as those introduced from outside are called as extrinsic features.

Automization level: This can be automatic or semiautomatic depending on user intervention level.

3. Approaches to Image Registration

J.V.Chapnick, M.E.Noz, G.Q. Maguire, E.L.Kramer, J.J.Sanger, B.A.Birnbaum, A.J.Megibow [10] have mentioned the following approaches of image registration way back in 1993.

• Transformations using Fourier analysis
• Cross correlation approach using Fourier analysis
• Sum of squares search technique
• Eigen Value Decomposition
• Moment matching techniques
• Warping Techniques
• Procedural approach
• Anatomic Atlas
• Internal landmarks
• External Landmarks

4. ALGORITHM CLASSIFICATION

Following is the classification of image registration algorithms:

• On the basis of Intensity: Intensity based methods compare intensity patterns in images via correlation metrics. These methods register entire images or sub images. If sub images are registered, center of corresponding sub images are treated as corresponding feature point.

• On the basis of features: Feature based methods find correspondence between image features such as points, lines and contours. These methods establish correspondence between a numbers of points in an image. Knowing the correspondence between the numbers of points in an image, a transformation is then determined to map the target image to the referenced image, there by establishing point by point correspondence between the referenced and target image.

• Single modality method: Single modality methods tend to register images in the same modality acquired by the same scanner or sensor type.

• Multi modality method: Multi modality methods tend to register images acquired by different sensors or scanner types.

4. METHODOLOGY

Image registration essentially consists of following steps as per Zitova and Flusser. Figure 2 illustrates the process.

• Feature detection: Salient and distinctive objects (closed-boundary regions, edges, contours, line intersections, corners, etc) in both reference and sensed images are detected.

• Feature matching: The correspondence between the features in the reference and sensed image established.

• Transform model estimation: The type and parameters of the so-called mapping functions, aligning the sensed image with the reference image, are estimated.

• Image re-sampling and transformation: The sensed image is transformed by means of the mapping functions.

Feature Detection : This approach is based on the extraction of salient features /structures in the image. Significant regions, lines or points are considered.

Region Features : The region like features can be projections of general high contrast closed-boundary regions of an appropriate size like water reservoirs, lakes, and buildings. The regions are often represented by their centers of gravity, which are invariant with respect to rotation, scaling, and skewing and stable under random noise and gray level variation. Region features are detected by means of segmentation methods. The accuracy of the segmentation significantly influences the resulting registration.

Line Features : The line features can be the representations of general line segments, object contours, coastal lines, roads or elongated anatomic structures in medical imaging. Standard edge detection methods, like Canny-edge detector or a detector based on the Laplacian of Gaussian, are employed for the line feature detection.

Point Features : The point features group consists of line intersections, road crossings etc which are detected using the Gabor wavelets, inflection points of curves.

Feature Matching : In the following section two major categories, area based and feature based methods, are further be classified into subcategories according to different methods and advantage and disadvantage.

Area Based Methods : These methods deal with the images without attempting to detect salient features. Windows of predefined size o the entire image are used for the correspondence estimation. Area based methods are preferably applied when the images have not many prominent details and the distinctive information is provided by gray levels/colors rather than by local shapes and structure. From the geometric point of view, only shift and small rotation between the images are allowed when using area based methods. To speed up the searching, area-based methods often employ pyramidal image representations and sophisticated optimization algorithms.

The limitations of the area based methods originate in their basic idea. Firstly, the rectangular window, which is most often used, suits the registration of images which locally differ only by a translation. If images are deformed by more complex transformations, this type of the window is not able to cover the same parts of the scene in the reference and sensed images.

Classical area-based methods like crosscorrelation (CC) exploit for matching directly image intensities, without any structural analysis.

Consequently, they are sensitive to the intensity changes, introduced for instance by noise, varying illumination, and/or by using different sensor types.

Transform Model Estimation : After the feature correspondence has been established the mapping function is constructed. It should transform the sensed image to overlay it over the reference one. The corresponding CP pairs should be as close as possible after the sensed image transformation is employed in the mapping function design. The task to be solved consists of choosing the type of the mapping function and its parameter estimation. The type of the mapping function should correspond to the assumed geometric deformation of the sensed image, to the method of image acquisition (e.g. scanner dependent distortions and errors) and to the required accuracy of the registration.

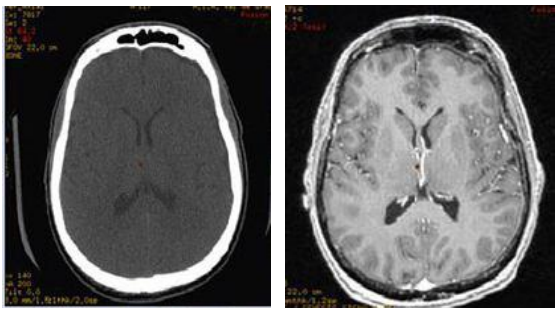
Image Re-Sampling and Transformation : The mapping functions constructed during the previous step are used to transform the sensed image and thus to register the images.

The transformation can be realized in a forward or backward manner. Each pixel from the sensed image can be directly transformed using the estimated mapping functions. This approach, called a forward method, is complicated to implement, as it can produce holes and/or overlaps in the output image.

Hence, the backward approach is usually chosen. The registered image data from the sensed image are determined using the coordinates of the target pixel and the inverse of the estimated mapping function. The image interpolation takes place in the sensed image on the regular grid. In this way neither holes nor overlaps can occur in the output image.

5. RESULTS AND DISCUSSIONS

In figure 3 (a), the first input original image is shown. In figure 3(b), the second sensed image is shown. After implying the steps of image registration, the output is registered image as shown in figure 4(c).



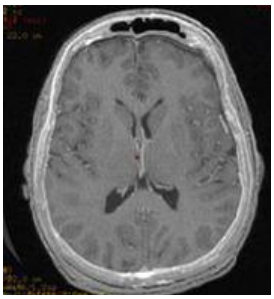
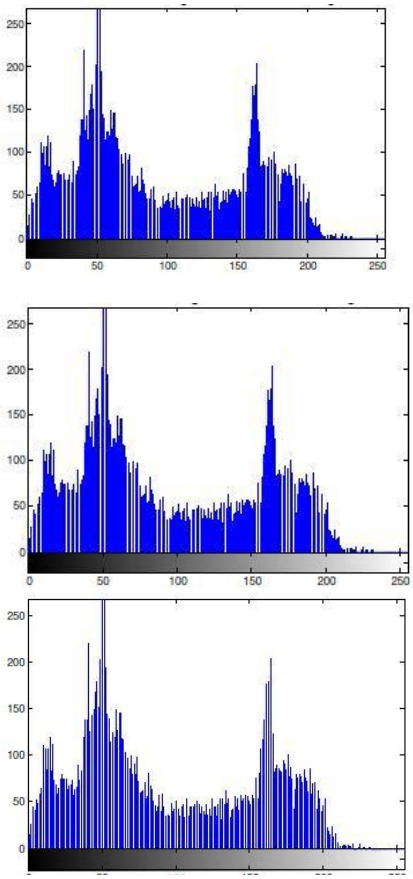


Fig. 3 : (a) First input Original Image (b) Second Input Sensed Image (c) Final Output Registered Image



Over the last two decades image registration has been a very successful topic with variety of applications. Fat and convenient access of data is now possible due to development in digital data archiving and communication.

This provides platform for registration of multimodal images in various disciplines. But registration is often a component of an image processing analysis package.

6. CONCLUSION

In this paper we have concluded all the features which can be detected in the process of image registration. In this paper

authors have presented a technique for registering the images differ by rotation, scaling and translation. The techniques presented can be applied a wide class of problems involving features may be corners, edges etc. In future work we can use various methods for detecting these features to make the process of image registration better.

These methods may be harries corner method for detecting the corners etc. It will help in making the technique of image registration better as well as to reduce the errors produced in this process of image registration.

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