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Image Registration: An Application of Image Processing

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Abstract: *Image registration is the process of overlaying one or more image to a reference image of the same scene taken at different time, from different view point and/or different sensor. Difference between images is introduced due to different imaging condition such that yields highest similarity between the input and the reference images. The objective of the registration process is to obtain the spatial transformation of an input image to a reference image by which similarity measure is optimized between the two images. There are a number of similarity measure is available which is used in the registration process . Out of which, a similarity measure which is based on information theory, called mutual information. Mutual information compare the statistical dependency between images .Registration based on mutual information is robust and could used for a large class of mono-modality and multimodality images. Image registration can be regarded as optimization problem where there is a goal to maximize the similarity measure. In this work we use mutual information as the similarity measure .There is a requirement to finding the global maxima of similarity measure. In this work we use simple genetic algorithm, share genetic algorithm, genetic algorithm combined with hill climbing algorithm for optimization. Being met heuristic these optimization technique require several decision to made during implementation, such as encoding, selection method and evolution operator. In this work we use two selection method roulette-wheel method and tournament selection method. Result indicates that these optimization techniques can be used for efficient image registration.*

Keywords: *computer tomography (CT), digital elevation models (DEM),Genetic algorithm (GA), Geographic Information System (GIS), mutual information (MI), magnetic resonance image (MRI), magnetic resonance spectroscopy (MRS),* nuclear magnetic resonance *(NMR), positron emission tomography (PET), single photon emission computed tomography (SPECT).*

I. INTRODUCTION

Registration is the determination of a geometrical transformation that aligns Points in one view of an object with corresponding points in another view of that Object or another object. We use the term "view" generically to include a three-dimensional image, a two-dimensional image, or the physical arrangement of an Object in space. Difference between images is introduced due to different imaging condition such that yields highest similarity between the input and the reference images. Image registration geometrically aligns two images the reference image and input image. Image registration is a crucial step in all image analysis tasks in which the final information is gained from the combination of various data sources like in image fusion, change detection, and multichannel image restoration. Typically, registration is required in 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 computer tomography (CT) and NMR data to obtain more complete information about the patient, monitoring tumor growth, treatment verification, comparison of the patient's data with anatomical atlases),in cartography (map updating), and in computer vision (target localization, automatic quality control), to name a few.

In general, its applications can be divided into four main groups according to the manner of the image acquisition:

Different viewpoints (multi view analysis):
Images of the same scene are acquired from different viewpoints. The aim is to gain larger a 2D view or a 3D representation of the scanned scene. Examples of applications: Remote sensing mosaicing of images of the surveyed area. Computer vision shape recovery (shape from stereo).

Different times (multi temporal analysis):
Images of the same scene are acquired at different times, often on regular basis, and possibly under different conditions. The aim is to find and evaluate changes in the scene which appeared between the consecutive images acquisitions. Examples of applications: Remote sensing—monitoring of global land usage, landscape planning, Computer vision automatic change, detection for security monitoring, motion tracking, Medical imaging monitoring of the healing therapy, monitoring of the tumor evolution.

Different sensors (multimodal analysis):
Images of the same scene are acquired by different sensors. The aim is to integrate the information obtained from different source streams to gain more complex and detailed scene representation. Examples of applications are Remote sensing—fusion of information from sensors with different characteristics like panchromatic images, offering better spatial resolution, color/multispectral images with better spectral resolution, or radar images independent of cloud

cover and solar illumination. Medical imaging—combination of sensors recording the anatomical body structure like magnetic resonance image (MRI), ultrasound or CT with sensors monitoring functional and metabolic body activities like positron emission tomography (PET), single photon emission computed tomography (SPECT) or magnetic resonance spectroscopy (MRS). Results can be applied, for instance, in radiotherapy and nuclear medicine.

Scene to model registration:

Images of a scene and a model of the scene are registered. The model can be a computer representation of the scene, for instance maps or digital elevation models (DEM) in GIS, another scene with similar content (another patient), 'average' specimen, etc. The aim is to localize the acquired image in the scene/model and/or to compare them. Examples of applications are Remote sensing-registration of aerial or satellite data into maps or other GIS layers.

Computer vision targets in template matching with real-time images, automatic quality inspection and Medical imaging. Comparison of the patient's image with digital anatomical atlases, specimen classification is also an application of image restoration.

1.1 Proposed work

The paper is organized as follows. The second section is a literature review of the area that gives the field background on the image registration process. The third section reviews the optimization methods of concerning image registration. The fourth section focuses on methodology and implementation issues. Results from the investigation are presented in the fifth section. Finally the paper is concluded with future work in the area.

II. IMAGE REGISTRATION PROCESS

The registration process involves finding a single transformation imposed on the input image by which it can align with the reference image. It can be viewed as different combination of choice for the following four components. [12].

(1) Feature space
(2) Search space
(3) Similarity measure
(4) Search strategy

The **Feature space** extracts the information in the images that will be used for matching. The **Search space** is the class of transformation that is capable of aligning the images. The **Similarity measure** gives an indication of the similarity between two compared image regions. The **Search strategy** decides how to choose the next transformation from the search space, to be tested in the search to spatial transformation. This work focuses on image registration of two medical images of having different modality i.e image acquired with different sensor e.g. images, MRI images. We consider set of image pixel intensity as the feature space and affine transformation as the search space. A popular similarity measure is mutual information (MI) consider as the mutual information .MI is based on the information theory. MI compares the statistical dependency between images. Registration based on the MI is robust and can be used for a large class of images acquired by the same sensor and different sensors. For the search strategy we use simple genetic algorithm and share genetic algorithm. Genetic algorithm (GA) is based on the concept of the natural process of specie evolution to realize simple and robust methods for optimization. GA is a stochastic technique for optimization, convergence towards global optima is very slow. To improve the time constraint of the registration process we apply simple genetic algorithm combined with the hill climbing algorithm. Hill climbing algorithm is a local search algorithm and execution is fast. In this work, we perform a comparative study of the image registration process on the multimodal medial images by using different genetic algorithm relative to the performance as accuracy and time. We use two genetic algorithm as simple genetic algorithm , sharing genetic algorithm using two selection criteria as roulette-wheel selection and tournament selection.

Probability distribution of gray values can be estimated by counting the number of times each gray value occurs in the image and dividing those numbers by the total number of occurrences. An image consisting of almost a single intensity will have a low entropy value; it contains very little information. A high entropy value will be yielded by an image with more or less equal quantities of many different intensities, which is an image containing a lot of information.

In this manner, the Shannon entropy is also a measure of dispersion of a probability distribution. A distribution with a single sharp peak corresponds to a low entropy value, whereas a dispersed distribution yields a high entropy value. Summarizing, entropy has three interpretations: the amount of information an event (message, gray value of a point) gives when it takes place, the uncertainty about the outcome of an event and the dispersion of the probabilities with which the events take place

III. OPTIMIZATION THEORY

This section reviews the theory behind the optimization methods Genetic Algorithm, Share Genetic Algorithms and Hill climbing Algorithm. Some research regarding the implementation of the methods on image registration is reviewed.

3.1 Search Space

When solving an image registration problem, we look for a particular solution that will be better than all or almost all other feasible solutions. Depending on the number of parameters n that constitute a solution, an n-dimensional *search space* consisting of the set of all possible solutions is created. If we mark each point in the search space with the corresponding cost for that solution, we get a landscape-like hyper surface. Our aim with the search is to find the lowest valley in this landscape. This is often a rather time consuming process, since the hyper surface rarely behaves in a smooth and predictable way.

3.2 Genetic Algorithms

This section describes the *Genetic Algorithms [7]* (GA), a random optimization technique inspired by the theory of evolution and the survival of the fittest. Genetic algorithms belong to the broad class of *Evolutionary Algorithms* (EAs) which take inspiration from nature’s own way of evolving species.

3.2.1 Background

The idea of *evolutionary computing* was developed in the 1960’s and has since then developed into a significant area within Artificial Intelligence. We will focus particularly in the concept of *genetic algorithms*, invented and developed by John Holland. The problem solving methodology employed in a genetic algorithm closely resembles an evolutionary process, where successively more and more fit solutions are “evolved” through an iterative procedure.

3.2.2 Algorithm Description

The operations of the genetic algorithm are very simple. It maintains a population $x1...n = \{x1. . . xni\}$of n individuals xi (which may consist of a vector of parameters). These individuals are candidate solutions to some objective function $F(xi)$ that is to be optimized to solve the given problem. The individuals are represented in the form of ‘chromosomes,’ which are strings defined over some alphabet that encode the properties of the individuals. More formally, using an alphabet $A = \{0, 1, . . . , k- 1\}$, we define a chromosome $C = \{c1, . . . , c`i\}$ of length $l$’ as a member of the set $S = A^{l`}$, i.e., chromosomes are strings of l symbols from A. Each position of the chromosome is called a *gene*, the value of a gene is called an *allele*, the chromosomal encoding of a solution is called the *genotype*, and the encoded properties themselves are called the *phenotype* of the individual. In the GA, typically a binary encoding is used, i.e., the alphabet is $A = \{0, 1\}$.

IV. ALGORITHM DESCRIPTION

Being meta heuristic GA require several decision to be made during implementation for encoding, selection, crossover and mutation.

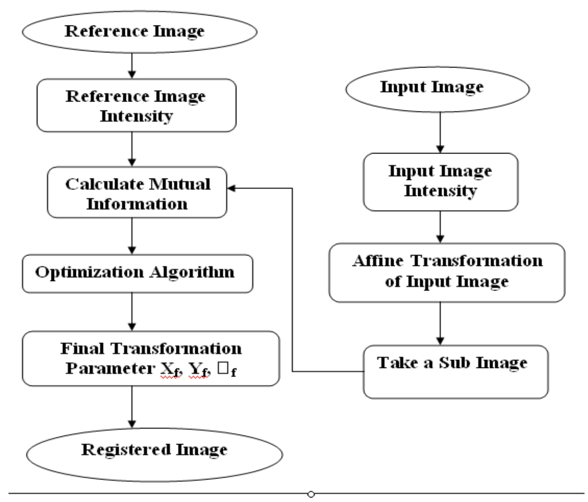
Encoding

The first decision to take when implementing a GA is how solution states should be encoded into chromosomes. Some encoding techniques are

(a)Binary Encoding
(b) Octal Encoding
(c) Hexadecimal Encoding
(d) Gray Encoding
(e) Floating Point Encoding

V. METHODOLOGY

As we know that image registration is the process of overlaying one or more images to reference of the same seen .The flow graph for the registration process shown in fig below. There are four main step such as (i) feature space (ii) search space (iii) search strategy and (iv) similarity measure in the image registration process. The experiment is done in MATLAB 7.5.The registration process is implemented for the multimodal images (image of different sensor). The implementation aspects of these steps are as follows**.**



Flow Graph of Image Registration using mutual information

Figure 1

V. RESULTS AND DISCUSSION

We test the image registration of the 7pair of medical images using the following algorithm.

(i)Simple Genetic Algorithm using roulette-wheel selection (GAr)
(ii)Shared Genetic algorithm using roulette-wheel selection (SGAr)
(iii)Genetic Algorithm combined with Hill-climbing algorithm using roulette-wheel selection (GAr+Hill)
(iv)Simple Genetic Algorithm using tournament selection (GAt)
(v)Shared Genetic algorithm using tournament selection (SGAt)

VI. CONCLUSION AND FUTURE WORK

6.1 Conclusion

In this work, we implement two genetic algorithms with two selection criteria .i.e. simple genetic algorithm and share genetic algorithm. We also implement a hybrid algorithm genetic algorithm combined with hill climbing algorithm. We conclude from the extracted result as follows

(i) All the three algorithms, simple genetic algorithm, share genetic algorithm, and genetic algorithm combined with hill climbing algorithm are feasible alternative in performing image registration.

(ii) Genetic algorithm represents an effective technique in multimodal optimization problem. One problem with genetic algorithm is that it can be trapped in local minimum due to genetic drift. By sharing genetic algorithm the problem can be solved. So that sharing genetic algorithm has given better performance than the genetic algorithm. But the algorithm is highly sensitive to calibration parameter. Therefore some time it does not give better performance.

(iii) The proposed algorithm genetic algorithm combined with hill climbing algorithm give very good performance with respect time as well as accuracy. The genetic algorithm is time consuming which is over come by using the hill climbing algorithm. The drawback of hill climbing algorithm is that it gives local optima, which is overcome by using GA.

(iv) In all the case the hybrid GA (GA+Hill) will give better performance in terms of accuracy to the simple GA and it some case it give better result than all the rest algorithm. In term of time it is fast among all the algorithm.

(v) We use genetic algorithm and hill climbing algorithm sequentially. First the genetic algorithm executes after that the hill climbing algorithm where genetic algorithm gives near to option. As hill climbing algorithm is local search algorithm this may occur that the maxima which is achieved in genetic.

6.2 Future Work

Some of the future work possible in the area is listed as follows.

(i)In this work we use mutual information as the similarity measure, other similarity measure such as gradient coded MI, weighted MI can also be used.

(ii)Parallel GA can also be used, to improve performance.

(iii)We use chromosome vector of four parameter translation along the x-axis and y-axis, rotation, scaling. The number of parameter can also increased to six parameter by taking two other parameter skewing and squeezing.

(iv)Adaptive GA and other hybrid GA can be used to improve the time and achieve sub pixel accuracy.

(v)Crowding GA can also be used to overcome the problem of genetic drift arises in the simple GA in multimodal optimization problem.

(vi)We use hill climbing algorithm with GA sequentially, i.e first we use GA then hill climbing. It can also implement such that the hill climbing algorithm used within the GA.

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