# A Geometrical Recording Applied in a CT scan

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***Abstract***

*This paper deals with a geometrical method for registration of CT (Computed Tomography) scanners cuts. Acquired images concern a patient who pains from a right parietal epidural hematoma. Acquisition was made in Emergency Department or Service at a Tunisian hospital located in Sfax named "Habib Bourguiba Hospital". Among the most popular algorithms, our idea has reset selected ICP algorithm that solves the very important problem in computer vision known as 3D registration.*

**Key words :** *CT scanner, image registration, transformation matrix, ICP. Geometrical Method*

## Introduction

A common problem encountered in computer vision deals with images alignment having various medical applications. This may involve well monitoring a patient evolution, malignant sites location and give a better assistance in the visualization and surgical decision. According to its excellent spatial resolution, the CT scanner has become the most used method in brain study. This recoding task requires estimating a geometric transformation for making a spatial superposition of multiple images corresponding features. In this context, several recording methods have been suggested in computer vision area [1]. Methods mainly differ by their distance criteria or the optimization technique used **[2]**. Generally, actually used recording techniques proceed in two steps: a combination of data and recalibrate an estimating rigid transformation matrix (rotation and translation). This returns practically all data in the same benchmark. In this paper, we study one of the most widely used methods to solve the 3D problem named ICP algorithm or (Iterative Closest Point). Data are used to readjust 3D/color CT scans. This requires making a data acquisition as it will soon be clarified

## 1.Image acquisition

The CT scan technique allows an accurate data acquisition from many organs. The principle retains choosing a cutting plane. After, one most perform multiple projections at various angles and an attenuation coefficient at each point of the plan will be obtained. This method offers good spatial resolution (millimeter) and a low contrast as observed. In our study, test images are CT images acquired in the emergency department of the Habib Bourguiba hospital in Sfax. They consist on 3D /color brain slices pairs characterized as following: during 12s acquisitions time period, two images were selected. The first pair 113x133x3 pixels sized and second pair 141x107x3 pixels sized. These images had a 3 mm thick as shown in Figure 1.

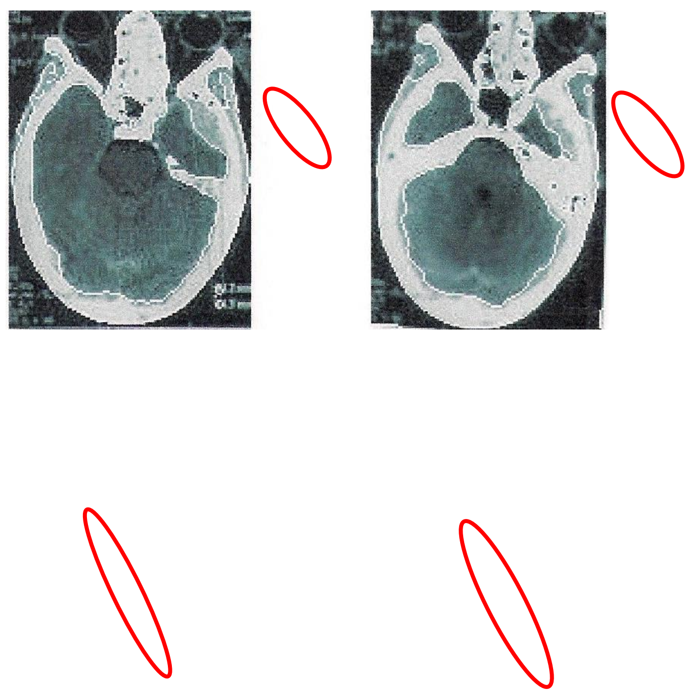


**Figure.1.** *Pairs Test of brain CT scans*

This figure represents two pairs of test images, as sections of different levels of achievement showing location of the hematoma. An evolution calculus of the hematoma is one of the recoding goals of these images that will be developed in what follows.

## 2. Image Records

Image recording is used in order to find a geometric transformation leading to align two images. Defining this transformation technique is an essential mean looking to help, structure and simplify the problem. This will also cause certain constraints and complexities of computing time in the second step. Two approches are distinguished in this context [3] :

- The geometric methods based on an extraction of a set of image features (points, contours, shapes) and their mapping to determine the best transformation to be applied,
- The iconic methods that take into account all image pixels directly and compare their intensities (or a function of the intensity).

Let us retain and understand that that image record is characterized by four criteria [4]:

- **Attributes** are the features extracted from images to readjust. They mainly guide the records. Two types are distinguished: geometric (points, curves, surfaces) or dense (intensity images).
- **The similarity criterion** that calculates the difference between images attributes to compare them. Multiple fonctions can be used for that**:**
    - ✓ Correlation between the two images,
    - ✓ Minimizing the variance of intensity ratios,
    - ✓ Minimizing the distance between landmarks,
    - ✓ Quadratic Similarity function,
    - ✓ Similarity between points by matching inertia centers of the two sets of points (in 3D using quaternion).
- **The deformation model** this defines how must be the transformation between the images to readjust (affine, rigid, elastic...),
- **Optimization strategy** this allows how the best transformation based on the similarity criterion would be determined in the search space defined by the deformation model. In general, the optimization can be assumed to be defined as **[5]**:

$$\hat{t} = \min_{t \in T} f(I_1, t(I_2)) \quad (1)$$

With:

- $\hat{t}$ meaning an optimal transformation,
- $I_1$ and $I_2$ are images to reset (or attributes),
- t is the transformation,

- T search space of possible transformation and $f$ is Similarity Criterion.

- **ICP algorithm and the algorithm iterated closest point.**

The principle of this algorithm is simple. It consists on iteration of the two recording steps: mapping the data and estimation of the transformation between reference frames to readjust. After each iteration, the algorithm provides a list of matched points and an estimation of the transformation between the reference images to readjust. This transformation is used in the next iteration for updating the list of matched points. These, in turn, serve to calculate a new estimate of the transformation. Steps are repeated until convergence of the algorithm when the residual error of distance between matched points is below a certain threshold [6].

In his formalism, this algorithm is as following [7]:

1. For every point of the original set, find the nearest point of the co domain.
2. From these matches, estimating a rigid transformation by the least square approximations.
3. Apply this transformation to the original set.
4. Iterate until the distance between the two sets of points is sufficiently low.

**3. Problème Position**

The objective of this work is to record two 3D data sets. Both sets are 2 pairs of brain CT scans. Respect to the brain, each pair of images ($I_1$: reference image, $I_2$: image reset) is the same level but with different acquisition time. Each pair of edges is bounded by the transformation T (consisting of a rotation matrix R and a translation vector t). The goal is to find T which realigned the best pair of cuts by minimizing the gap: [$I_1$, I'2] such that I'2 = R $I_2$ t. To do this, we adopt the ICP algorithm presented in the sequel.

### 3.1 Homologous Forms Extraction

The search for the transformation T is based on the extraction of geometric parameters. In our case, we try to detect the contour as a parameter from a 1D to 3D cutting through a set of morphological operations defining a segmentation followed by detection of surface contour obtained.

***Segmentation:*** This forms an optional step in other recording methods **[8]**. The goal is to achieve a connected set whose boundary is precisely the brain's surface and convert the 3D image into a 2D image. The methodology consists of thresholds to eliminate noise due to poor positioning of the sensor acquisition or patient and to show the brain surface in 2D digital form. An opening on the scanned image 2D (dilation & erosion), which ensures that we keep an accurate description of the brain surface, will be then, applied.

***Edge Detection*** [9]: In the context of global alignment of 2D images, the similarity measures take into account the contours to determine the quality of image records. One could define the contour as the points where the intensity varies suddenly. We detect these points by the canny algorithm that calculates the modulus of the gradient image. Results are shown in Figure 2.

Figure 2 shows the morphological operations applied on the images to extract their contours in the surface of the brain. This is done in order to detect points with coordinates that are considered as parameters input for our algorithm.

### 3.2 ICP algorithm Recording

Once the contours of the image and reference image Iref readjust Irecal were detected, one tries to extract two sets of points of interest having coordinates P (x, y) and X (x, y). These sets of points will be considered as parameters input of our ICP algorithm.

Note that, the way in which selected points of entry to PKI, can have an impact on the convergence of the latter. Several approaches exist for selecting these points with their coordinates from the edges, for our purposes, the Harris detector was used. The convergence of ICP depends on the quality of matches used. Indeed, the presence of false matches in the best case slows the

convergence of PKI and can at worst cause its divergence. A robust method for matching these points is essential; it is the classical Euclidean geometric distance suggested by Besl [7]:

$$d(\vec{p},\vec{x}) = \|\vec{p}-\vec{x}\| = \sqrt{(i_p - i_x)^2 (j_p - j_x)^2} \quad (2)$$

This method which begins by assessing the points will be called "consistent" and it will calculate the closest points. The constraint, that the points are all the edges (contours) of the surfaces to reset, is to apply a threshold looking for elimination of pairs of points whose Euclidean distances are relatively large. This threshold approaches the resolution of the sensor acquisition (scanner) [10].

### 3.3 Criterion to minimize

The simplest criterion is the sum of errors squared distance between pairs of matched points. This error is a function of the rotation matrix R and translation vector t [7]:

$$e(R,t) = \frac{1}{N_p}\sum_{i}^{N_p} \left\| \vec{x}_i - (R\vec{p}_i + \vec{t}) \right\|^2 \quad (3)$$

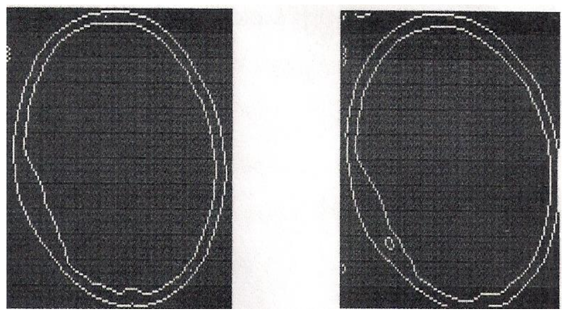
***Transformation Matrix Establishment***

To estimate a rigid transformation, we use the singular value decomposition SVD because it requires less time to run and produces slightly more accurate results [11]:

$$R = \begin{pmatrix} \cos(\theta) & -\sin(\theta) \\ \sin(\theta) & \cos(\theta) \end{pmatrix} \qquad t = \begin{pmatrix} t_x \\ t_y \end{pmatrix} \quad (4)$$

Finally, this transformation matrix is applied to the image to be readjusted Irecal for synchronization with the reference image Iref as below illustrated (Figure2).

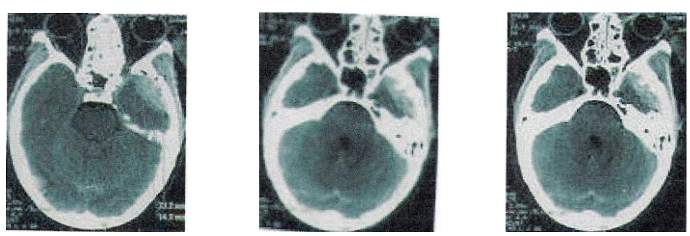
Segmented Image



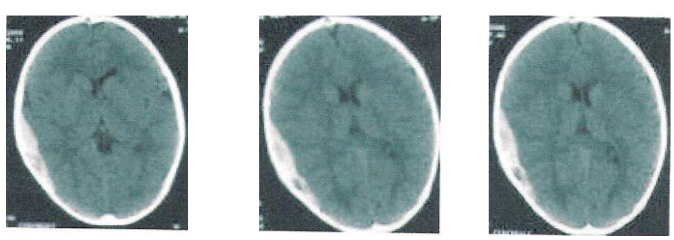
Detected Contour

**Figure.2.** Forms Extraction

The ICP algorithm calculates the rigid transformation matrix (R, t) iteratively. This has allowsed us to determine an optimal matrix to be applied on the image to be readjusted to either like or similar geometrically reference image as illustrated in Figure 3.



(a) Iref (b) Irecal before (c) Irecal after



(a) Iref (b) Irecal before (c) Irecal after

**Figure.3.** *Recording Result*

## Conclusion

In this paper, we presented an overview of a geometric monomodal recording approach of CT images 3D/color. This approach is based on the principle of the ICP algorithm which, in turn, uses only the outline of the image information without exploiting color information. PKI is a simple algorithm, it does not impose preconditions. By cons, it requires a large calculation. Consequently, several methods have been developed to accelerate as in the example of PKI-GSA (G: Geometric distance, SA: Adaptive Threshold), ICP-MSA (M: Mixed distance, SA: Adaptive Threshold). It hopes to soon present other results and further develop these techniques. Through a strategy of image fusion as will be described in future research, improvements and better results will forwardly come.

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