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# Computer Assisted Method for Cervical Vertebrae Segmentation from X-Ray Images

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**Abstract**: A computer assisted method is introduced for the segmentation of cervical vertebrae from x-ray images. Segmentation of cervical vertebrae in x-ray images is very helpful for the bone morpho-metrists. Due to low gray level variation of x-ray images it is very difficult to segment the cervical vertebrae. In this work Active Appearance Model (AAM) based segmentation is presented for the segmentation of cervical vertebrae. This includes the observation of shape and texture variation in a training set of images. The proposed work includes four phases (a) Shape analysis (b) Texture analysis with the help of Appearance (c) Combined analysis of shape & texture (d) Shape search in new x-ray image.

**Keywords**: Active Appearance Model, Cervical vertebrae, Segmentation, Shape analysis, Texture analysis.

## I. INTRODUCTION

X-ray imaging is the fundamental step to provide some evidence when the patient first visits. It provides some basic information before performing the advanced imaging. An x-ray image provides valuable information to a specialist. It allows him to visualize indirectly features of the human body. It is difficult to distinguish the objects in x-ray images from their background. For the extraction of objects from the x-ray images many algorithms and methods were defined. X-ray imaging is a cheapest & fastest method to detect cervical vertebrae abnormalities. For this reason we prefer x-ray images which focus on cervical vertebrae. Computer-based image segmentation gives the facility to a domain expert for his work and can automate the different tasks those are dealing with interpretation of medical images.

In recent years, the model-based approach towards image interpretation named deformable template models has proven very successful. This is especially true in the case of images containing objects with large variability.

**[1]** Among the earliest and most well known deformable template models is the **Active Contour Model** – known as ***Snakes*** proposed by Kass et al. [6]. Snakes represent objects as a set of outline landmarks upon which a correlation structure is forced to constrain local shape changes.

**[2]** In a more general approach, while preserving specificity Cootes et al. [7] proposed the **Active Shape Models (ASM)** where shape variability is learned through observation.

**[3]** A direct extension of the ASM approach has lead to the **Active Appearance Models** [8]. Besides shape information, the textual information, i.e. the pixel intensities across the object, is included into the model. [9, 10].

**[4]** Quite similar to AAMs and developed in parallel herewith, Sclaroff & Isidoro proposed the **Active Blob** approach. Active Blobs is a real-time tracking technique, which captures shape and textual information from a prototype image using a finite element model (FEM) to model shape variation. Compared to AAMs, Active Blobs deform a static texture, whereas AAMs change both texture and shape during the optimization.

Our aim is to obtain the segmentation of the cervical vertebrae on x-ray images. Smyth et al previously used an Active Shape Model (ASM) for the segmentation of lumbar vertebrae, employing a single model of the spine from L4 to T7. Active Appearance Models (AAM) provide a compact statistical model of data encompassing both shape and texture variations [6]. It incorporates all correlations between textures at different points, and also models the correlation between shape and texture via a tertiary PCA. AAM is better than ASM in segmentation of cervical vertebrae where the associated image texture can be quite variable & associated with the shape of the vertebrae. For example fractured vertebrae have not only a different shape, but the appearance of the endplate is different to that of a normal vertebrae: the fractured end plate has a more diffuse, often multi-edged, texture; whereas a normal vertebra would have a clearly defined margin. An ASM in contrast would try and adjust its shape so that each point located a position that best matched the mean texture, whereas the AAM adjusts its appearance parameters to best match to the actual texture of the image. Therefore we used AAMs rather than ASMs. Here both shape & texture information of the cervical vertebrae is combined in to a single statistical model that can give the variation encountered in the training data.

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## II. ACTIVE APPEARANCE MODEL METHODS & OVERVIEW

The AAM method consists of following steps:

- *Database Creation:* This step includes the placement of landmark points on the images to describe the tentative edges of vertebrae. The specialist knowledge is included in this step.
- *Shape Alignment:* In this step all the marked shapes have to be aligned before the creation of the model. It could be helpful for the specialist to build a model. Once the model is created, these same patterns can be found in an X-Ray.
- *Appearance model:* This step includes texture information for more accurate results.
- *Combined model:* This step gives a concatenated result of shape as well as texture information.
- *Shape search:* This step includes placing the mean shape model created in previous step on the area of interest. This step is manual.

### *A. Database Creation*

In this phase we create an image sample which helps us for model creation. This image sample is the basis for model creation. The training set is used for the creation of this model. The set of training images collected from the orthopedic centers & from the sample x-ray images available on Web-based Medical Information Retrieval System (WebMIRS ). According to D. G. Kendall Shape is nothing but the geometric information that remains when location, scale and rotational effects are filtered out from an object. Also shape is invariant to Euclidean similarity transformations. One way to describe a shape is by locating a finite number of points on the outline which are known as landmark points. A landmark is a point of correspondence on each object that matches between and within populations. The landmarks are created manually on the images. By using this data of landmark points shape variations are analysed over the training set.

Each vertebra must be described by the landmark points. It is very much necessary that each vertebra in the image must have same number of landmark points. We can select the minimum 4 to maximum any number of landmark points on each vertebrae. It is a common practice to choose as landmarks the corners of the vertebra and a reasonable number of equidistant points between the corners. Here we are using 13 landmark points for each vertebra. The specialist has to put all the land mark points manually, thus this process becomes very much time consuming. A sample image containing the landmark points & the shape of cervical vertebrae is shown in the figure 1

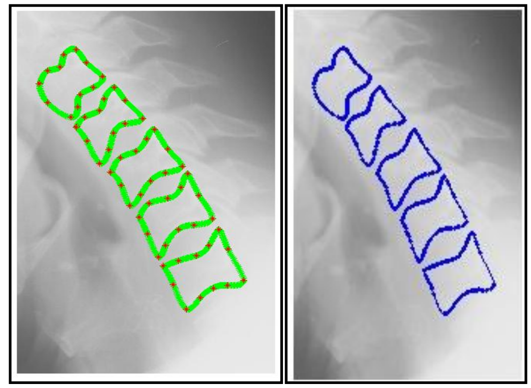

Fig. 1 cervical vertebrae showing the landmark points indicated by red & interpolated points indicated by green & the shape obtained.

### *B. Shape Alignment*

The annotated shapes are generally positioned at various locations and orientations on vertebra edges. For this reason, it is necessary to align all these shapes in order to make a correct statistical treatment [7]. It is necessary to create the correct statistical model by aligning all these shapes. By aligning all the shapes together a mean shape is computed which forms the basis for vertebrae edge detection. Figure 2 shows the aligned shapes.

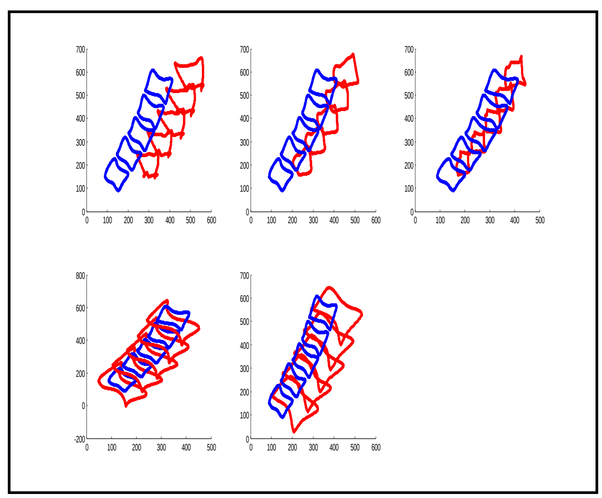

Fig. 2 Shape Alignment

### *C. Appearance Modelling*

By considering only shape, the appearance model will not become complete. Shape is only defined by considering the knowledge of the pixel neighbourhood. We must have to consider the information contained in the pixels themselves. Principle Component Analysis is used for obtaining this pixel information. Image wrapping is used to find the texture information. Texture is the pixel intensities across the object in question (if necessary after a suitable normalization). The piece wise affine is done by partitioning the convex hull of the points, using suitable triangulation. This triangulation

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connects the irregular point set by a mesh of triangles & no triangle has any points inside its circumcircle, which is the unique circle that contains all three points of the triangle. After image wrapping pixel interpolation is done. For obtaining the true shape the texture model should be free from global changes in the illumination.

### *D. Combined Modelling*

To remove the correlation between the shape & texture model parameters and to make model representation more compact a PCA is performed on concatenated shape & texture parameters to obtain combined model parameter.

### *E. Shape Search*

The mean shape computed in the *Shape Alignment* step is now used in this step of searching the shape of vertebrae. By manually placing the previously computed mean shape on the test vertebrae image as close as possible to the real object we get the segmented shape of those vertebrae. Figure 3 shows the scaling after selection of the initial position of vertebrae manually & the final result of the AAM after segmentation.

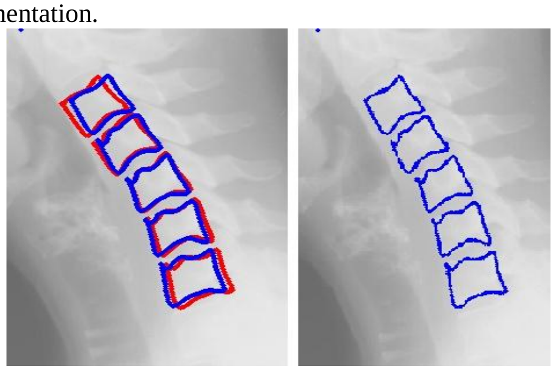

Fig. 3 scaling after selection of initial position & Final result after segmentation

## III. FUTURE WORK

Segmentation with the help of Active appearance model becomes very much convenient for the bone morpho-metrists. After segmentation further we can find the distance between two nearest vertebrae which will help in the identification of the vertebrae disorder, anterior osteophytes, disc space narrowing, and subluxation. This segmentation can also be extended for the lumbar spine for the determination of anterior osteophytes & subluxation. Also we can use these results for the classification of normal & abnormal spine x-ray images. This Method can also be applicable to Lumbar Spine Segmentation.

## IV. CONCLUSION

Segmentation of x-ray images using Active Appearance Model mainly depends on shape & texture variations. This automatic segmentation with the help of AAM is more suitable than ASM because it includes the texture modeling which is not present in ASM. Because of this our result becomes more accurate than that of the ASM. Automatic acquisition of basic landmark information, obtaining approximate vertebrae location, determining approximate vertebral boundaries, matching vertebral shapes with the training set, acquiring the texture information & searching for the actual shape of the new vertebrae is done with the help of a computer assisted method. In this paper we have reported specific results for obtaining approximate spine segmentation in an automated fashion.

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