Patch-wise Robust Active Shape Model using Point Reliance Measurement

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Abstract

The active shape model(ASM) is one of the most popular methods among the shape prior based segmentation methods based on its strong shape constraints using the statistic of shape information which is acquired from the training set. ASM has a few drawbacks, such as, the lack of shape variability, and the sensitivity for false locally searched points. In this paper, we suggest the patch-wise robust ASM to overcome the limitations of the ASM. In addition to the SSM, we introduce the patch-wise SSM, to reduce the shape inflexibility and to search reliable points with the point reliance measurement. The quantitative and qualitative results show the robustmness and the accuracy of the proposed method.

1. Introduction

Segmentation methods based on a shape prior have been proposed to extract an object with an uncertain boundary in the medical image analysis, since the shapes of target objects are known by the nature of medical images. Cootes et al. suggested the active shape model (ASM)[1] as one of the shape prior based segmentation methods. The ASM is based on its strong shape constraints using a statistical shape model (SSM).

Although the various researches based on the ASM have been suggested in medical image analysis and shown successful results [2], the ASM has limitations. Many previous researches have been suggested to overcome these shortages. Davatzikos et al. suggested the HASM[3] to enhance the accuracy of segmentation in the "lack of training set" scenario. The conventional ASM is often resulted in the inaccurate result for 3D images by the insufficient number of training set, because of the high dimension of 3D shape. Thus, the HASM divides the global shape of an object into small segments to decrease the dimension of SSM. The HASM obtains more accurate results than the ASM when the number of training set is small. However, the HASM's result is similar to that of the ASM when the number of training set is sufficient.

RASM[4] has been suggested by Rogers and Graham to reduce the influence of noise and false local observed points. RASM has focused on shrinking the influence of the noisy observations to enhance the accuracy of ASM. Sun et al. extended RASM to the 3D lung images with the optimal surfacing algorithm [5]. They randomly sample a small portion of the landmark points of the global shape to make a subset. The randomly sampled subsets have smaller dimensionality than the global shape and can be used as mid-level cues to recollect the pruned points. Sun et al.'s method has shown successful results for damaged lung images. Nonetheless, the randomly sampled subsets have only vague information of the global shape, i.e., the subsets only have little meaningful shapes.

In this paper, we propose patch-wise RASM with point reliance measurement. We partition the global shape of an object into equal size patches to preserve the meaningful shapes statistics of the local segments. The patch-wise SSM represents the local statistics well since the shape variation of a local region is not so large and clear than SSM of randomly selected points. In addition, we measure point reliance that represents how much a searched point's position is likely to be the true position of the object on each partitioned segments. We secure the highly reliable points during the iterative process of the proposed method. This affects the result of each iteration step to include reliable points even after the shape refinement.

2. Patch-wise Robust Active Shape Model

A. Patch-wise Statistical Shape Model

The global shape information data are partitioned into equal sized small patches using Oriented Bounding Box algorithm(OBB). Fig. 1(a) shows an example of partitioned patches of the mean shape. At the training stage, the proposed method formulates the

appearance model and the two level SSMs, a global level SSM and a patch level SSM. The patch level SSMs are used not only to constrain the locally found points, unlike the global level SSM, but also to measure the point reliance.

B. Point Reliance

The ASM variations with standard iterative processes with SSM have considerable possibility that the locally found points are relocated to satisfy the shape consistency even though the locally found points are in the true position of the object. The proposed method measures the point reliance of the locally found points to secure the highly reliable points in two perspectives, appearance and shape consistency. The appearance reliance represents how close the locally found point's appearance is to the trained appearance model of corresponding landmark points in the training set. The shape reliance measures the difference between the locally found points and its corresponding position in the transformed patch level mean shape. The Euclidean distance of points between the transformed patch mean shape are used to measure the reliance which is the probability of shape consistency in the Gaussian assumption.

3. Experimental Results

For the evaluation, we used SKI10 knee-joint data set. We collect 60 images from the data set. The majority of the data set was T1-weighted MR images with a pixel spacing of 0.4x0.4x1.0(mm).

We analyze the propoesed algorithm's performance by the quantitative comparison of the conventional ASM(ASM) and the proposed method(Proposed). Table 1 presents the mean and the standard deviation of the Hausdorff distance(HD) and the Dice coefficients(DSC) of two methods. The Hausdorff distance of ASM and the proposed method were 17.01 and 14.74 on average, respectively. Also, the Dice coefficient of the proposed method, 89.48, is the higher than ASM, 82.97.

Fig. 1 (c) and (d) show the qualitative comparison of ASM and the proposed method. The ASM missed considerable portion of the true boundary because of its global shape constraints, while the proposed method narrowed down the error on the boundary.

Table 1. Table of the quantitative comparison of the conventional ASM and the proposed methods

	ASM	Proposed
HD	17.01±2.75	14.74±2.28
DSC	82.97±7.15	89.48±4.68

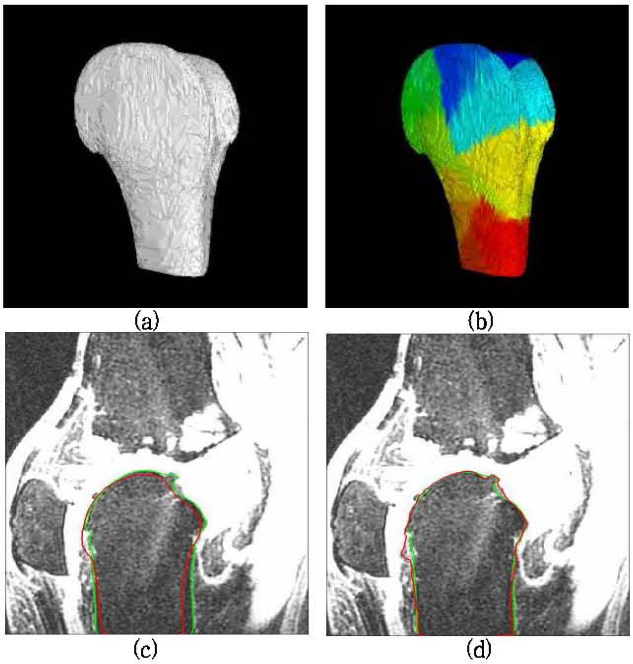

Figure 1. The mean shape of the ground truths in the femure training set(a), and the partitioned mean shape into patches(b). The below figures present the experimental result of the conventional ASM(c), and the proposed method(d).

4. Conclusion

In this paper, we present the novel patch-wise robust active shape model with the point reliance measurement. The proposed method relaxes the global shape constraints and also leads the result to be more accurate by securing highly reliable points. The proposed method showed its robustness by the quantitative and qualitative comparison with the conventional active shape model.

References

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