Help to decision by belief theory, Application to a sequence MRI.

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Abstract

The work presented in this article is keeping with the radiologie service of the "Calot de Berck sur Mer" institute. It is done in order to help the doctors for the illness following of the spinal column. The objective is reconstructing each vertebra of lumbar rachis from a serial parallel sections. From a initial segmentation, we're looking for parts which represents as better the vertebra anatomical contour, in order to give to the doctors a belief degree on each part of this segmentation. This methodologie is based on the evidence theory using, in order to fusion the informations. This method lets a doubt notion introduction between the differents elements studen. Further, it better represents the certainly of the calculated segmentation solution, and morever, it permits to fusion heterogeneous data. We have obtained some synthesis data by specifying the limit of our way. We finish with the future to bring, in order to become more flexible the employed fusion modelisation.

Keywords : ***decision help, data fusion, evidence theory, sequence MRI.***

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Introduction

The work presented in this article is keeping with the radiologie service of the "Calot de Berck sur Mer" institute. It is done in order to help the doctors for the illness of the spinal column. These have an MRI to study these pathologies. The objective is reconstructing each spinal of the lumbar rachis from a serial parallel sections. From a initial segmentation, we're looking for parts which represents as better the vertebra anatomical contour, in order to give to the doctors a belief degree on each part of this segmentation, and show clearly the parts which we can't conclude. Generally, the slices present some imperfections, it is not always possible to define exactly the anatomic contour. We propose to use the adjacent section that we have studen, in order to have more news which permit us to affirm or invalidate the decision we have taken.

The methodologie is based on the belief theory using, in order to fusion the information. This one keeps with the application restraint. This methode lets a doubt notion introduction between the differents elements studen. Further, it better represents the certainly of the calculated segmentation solution, and morever, it permits to merge heterogeneous data.

Frame of discernement

We dispose serial parallel sections of the column vertebra. On each of them, spinal segmentation is realised with the snake method. We consider no vertebra have junction.

Each section is constitued by K elements which represent K different sets (or K organs).

$$\Omega = \{skin,\ vertebral\ body,\ cortical\ bone, \ldots, muscle,\ air,\ fat,\ moving\ fluid\} \tag{1}$$

We regroup all of Ω elements. The new Ω ensemble is constituating by K=2 following elements :

$$\Omega = \{S, \overline{S}\} \tag{2}$$

with S substance familly wich gives back a signal (vertebral body, muscle, fat, ...), and $\overline{S}$ substance familly wich gives back no signal (cortical bone, air, moving fluid, ...).

Several methods of segmentation have been tested in order to extract from the picture the information of cortical bone. The segmentation by active contour has been taken for its good detection results and its always closed contour.

Each contour is sampling with the same number of points. The segmentation is parametred in a way it converges toward the area that we're searching.

$$Segmentation = \{Q_i\} \qquad avec \qquad i \in [1..N] \tag{3}$$

$$Q_i \in \overline{S} \qquad avec \qquad i \in [1..N] \tag{4}$$

We try to give an opinion on the Q_i elements in order to determinate which are really a part of the $\overline{S}$ area.

Mass set

We have to define a mass distribution corresponded at the expert opinion in order to x point belong at $\overline{S}$ or S, or $\overline{S} \cup S$. The expert opinion is modeled under the three mass form following :$m_x(\overline{S})$, $m_x(S)$, $m_x(\Omega)$, with $x = Q_i$ a point from the sampled segmentation of the cortical bone of the spinal.

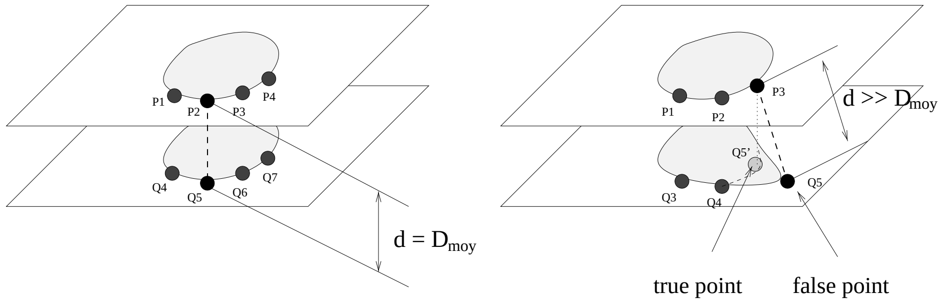

Figure 1: two slices

The single mass $m_x(\overline{S})$ and $m_x(S)$ give the belief degree of what the expert gives in order to the x element of the segmentation belong at $\overline{S}$ (respectively S).

The composed mass $m_x(\Omega)$ give the doubt of the expert has on the segmentation x point belonged to $\overline{S}$ or S.

$$m(\overline{S}) = \alpha.e^{-\eta.|d(P,Q)-D_{moy}|} \tag{5}$$

$$m(S) = \alpha.(1 - e^{-\eta.|d(P,Q)-D_{moy}|}) \tag{6}$$

$$m(\Omega) = 1 - \alpha \tag{7}$$

where α is the expert reliability, d is the distance between two points, η is the inaccuray allow on the distance d, and D_{moy} is the mean distance between each point of two slices.

Combination of two sources in three consecutives slices

With three successive slices (P, Q, R), we define two experts for all sample points of the contour segmentation : the first expert m_1 (slice P and Q) and the second expert m_2 (slice Q and R). Each expert gives us a belief degree on the belonging of point Q_i to the good segmentation. We combine these experts with the Dempster rule.

$$m^{1,2}_{Q_i} = m^1_{Q_i} \oplus m^2_{Q_i} \tag{8}$$

Decision

We find several choice to make the decision following the maximum plausibility, the maximum credibility or the maximum evidence. We choose to use the maximum resulting mass to evaluate the point belonged.

Results

At the end of the fusion step, a segmentation solution is suggerate at the doctor. This step gives an opinion for the Q_i point belonging at the S, $\overline{S}$, or Ω elements. The synoptic fig. 2 is simulating on synthesis data. The results that we obtained are positive. Further the method has been apply on real data (MRI T1 protocol). In some situations, experts are in contradiction. We don't want to impose a false solution. It is better to bring a good segmentation, not validate by the fusion operation, rather the contrary. In the hypothesis where the experts contradict, we choose to give a false alarm rather of no detection. This method permits to detect the abrupt variation of the spinal contour.

with 3 slices, we calculate the expert opinion and combine them. We take the decision with the maximum of evidence. The η coefficient of the mass set permits to ponderate the uncertainly mesure imprecision. On the fig. 2 the represented points by the cross correspond at the wrong segmentation decision. If on certain part of the decision contour is good, it apparates area where the decision isn't good. Our method penalize the current slice when the mistake is on the preceding slice and/or the following slice.

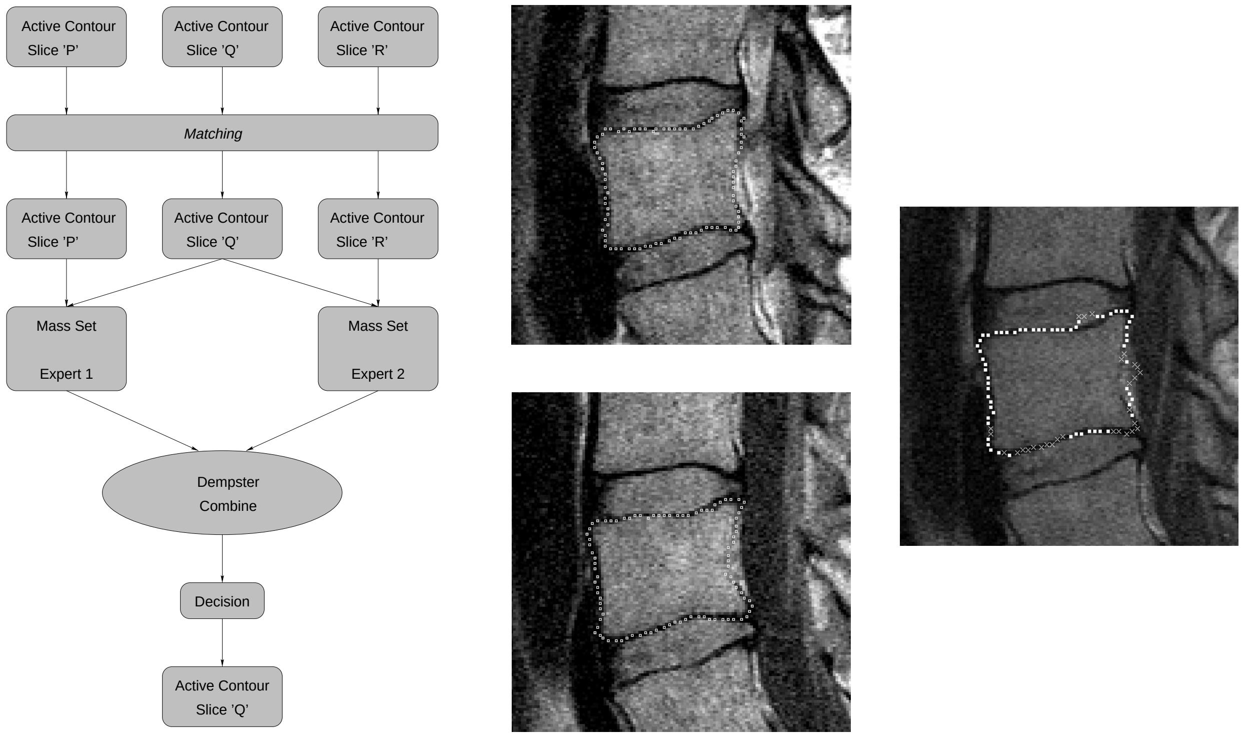

Figure 2: Synoptic and results

Conclusion

This work is a first study using the Dempster-Shafer theory on help to decision of pictures segmentation, with combinated different expert opinions. However the hypothesis choosen are strong enough. Indeed, we consider that the mistake can only be on the center slice. In contrary case, the two experts are the same opinion and we validate the points. The fusion model that we use carry a lost information on the possible origin of the mistake between two points of consecutives slices.

We envisage in the future, to modify the modelization to solve this problem, the expert appraisal could have been completed by other informations.

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