Original article

MedataWeb: A shared platform for multimodality medical images and Atlases

MeDataWeb : une plateforme partagée pour l'imagerie médicale multimodalité et les atlas

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Abstract

Computer-assisted medical interventions and treatment planning have known an increasing interest and research activity in different fields and applications. However, before the routine deployment of these procedures becomes a reality, in vivo and in silico validations must be undertaken. This paper describes a platform containing multimodality medical images and atlases useful for algorithms evaluation, comparison and validation. The platform contains des-identified data (images, contours and atlases) from the ProstateAtlas and ProstateWeb project: the first morphological and zonal atlas of the prostate, and from clinical data of lymphoma PET (PETWeb). Data are available at the URL: http://www.medataweb.U703.net.
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Résumé

Les gestes médicaux-chirurgicaux assistés par l'imagerie, la simulation et la robotique ont connu un intérêt et un développement grandissants ces dernières années. Cependant, avant que l'utilisation de ces techniques en routine clinique devienne une réalité, elles doivent être validées (in silico, ex vivo, in vivo...). Cet article décrit une plateforme contenant des images médicales multimodalité et des atlas utiles pour l'évaluation d'algorithmes, la comparaison et la validation de méthodes. La plateforme contient des données anonymisées (images, les contours et atlas) du projet ProstateAtlas et ProstateWeb : le premier atlas morphologique et zonale de la prostate. Il contient également des images de TEP de lymphome et les structures délimitées associées (PETWeb). Les données sont disponibles à l'adresse URL : http://www.medataweb.U703.net.
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1. Introduction

In many clinical procedures, imaging takes an increasingly growing position and image analysis has become crucial. Starting from this observation and from the ubiquitous need for 3D data set with well-known ground truth to validate image processing tools/algorithms/methods, our motivation was to build an open and shared base containing images: clinical or/and simulated for different organs and modalities that could be used for this purpose. Such solution has been already proposed for brain [1]. The brain phantom combines a model and MR imaging simulator and is publicly available (www.bic.mni.mcgill.ca/brainweb). Based on the same concept,

a full segmentation validation engine from the Laboratory Of Neuro Imaging (LONI – University of California, Los Angeles) has been recently described [2]. This solution offers a complete online solution for brain segmentation validation for dedicated application in Neurology (http://sve.loni.ucla.edu/).

Such databases remain rare for other anatomical localizations or applications. Only a statistical atlas of prostate cancer distribution was recently proposed by Shen et al. [3] for optimizing biopsies. This database is also free and can be retrieved from the authors' website (www.rad.upenn.edu/sbia/projects/prostate.html).

In the next sections, we describe two datasets corresponding to clinical applications where imaging plays an important role. The first is dedicated to prostate cancer imaging. The second contains non-Hodgkin's lymphoma PET imaging including multi-expert manual delineations and automatic segmentation approaches.

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2. ProstateAtlas and ProstateWeb

From a morphologic point of view, the prostate is an exocrine gland, shaped like a pyramid with an upward base. The zonal anatomy of the prostate has been described for the first time in the 1960s, but the use of terms in anatomical practice was introduced in the 1980s [4]. It is composed of four zones: peripheral zone (PZ), central zone, transition zone (TZ) and fibromuscular structure (Fig. 1). PZ and TZ are key structures, as 70% of prostate tumours are located within PZ. Inversely, benign hypertrophy (BPH) most often occurs in the TZ, which becomes larger with age.

From a radiologic point of view, for men aged over 50 years, only two areas of the prostate are considered: the central gland (hypertrophied TZ and peri-urethral glands) and PZ. In this study, we assume that TZ refers to the central zone. As shown by Fig. 1, TZ is surrounded by the PZ, whose thickness and size depend on patient's age and prostate pathological symptoms, like BPH. The PZ is surrounded by vessels and is very likely to host irregular tissues like tumours.

Here we report the data and the models used to create the numerical phantom of the gland, the PZ and the TZ. These materials and methods were published in Betrouni et al. [5].

Briefly, we propose clinical magnetic resonance (MR) images of 30 selected patients. Images consist of axial T1-weighted sequence (65 to 85 images, voxel size $0.48 \times 0.48 \times 1.3\ mm^3$). An expert radiologist manually segmented the images to delineate the prostate gland, the PZ, the TZ, urethra, cysts and tumours (Fig. 1). Images are provided in DICOM format and contours are provided in DICOM RTSS format.

This data was used in [5] to create atlases for the prostate, the peripheral and TZs.

Creation of the models and atlases was done is following way:

- structures delineation by an expert;
- creation of mesh files for each structure;
- creation of binary files from the meshes;

- statistical description of shapes;
- probabilistic description of the two zones. This description allows to take into account the inter-patients variability and could be incorporated as an *a priori* knowledge in an automatic segmentation process.

We also provide for each patient mesh and binary files for each structure (gland, PZ and TZ). Binary data are provided in two formats: as DICOM files and as Raw files. Mesh files described as Level sets, are in the object file format (OFF) (Fig. 2).

The last part of this data concerns the atlases. The first atlases are morphological atlases of the prostate, the PZ and the TZ. They were created using principal components analysis (PCA). The second class of atlases are probabilistic atlases describing zonal distribution of two zones: PZ and TZ inside the prostate gland (Fig. 3).

Files are provided in the Analyze (.hdr, .img) file format.

3. PETWeb

[18F]-Fluorodeoxyglucose PET ([18F]-FDG PET) has become an essential technique in oncology for initial staging, treatment planning and assessment of therapeutic response. The most challenging and crucial step is to correctly determine the metabolic tumor volume in order to provide more accurate target volume definition in radiotherapy treatment planning. Accurate and reproducible manual delineation is difficult on PET images due to the poor spatial resolution of the PET imaging which results in a gradual transition between healthy tissue and tumor. Numerous (semi) automatic methods have been proposed and evaluated. The evaluations are usually performed on phantom, on simulated data or/and on anatomopathological data with the corresponding ground truths being well established. For clinical data without available ground truth, the evaluation is made through comparisons with the volume segmented on morphological images or with expert(s) manual delineation(s). Comparisons of the performance of some methods sometimes complete evaluations.

In Dewalle et al. [6], we proposed an assessment framework based on comparisons with manual delineations performed by experts. Applied on clinical data with non-Hodgkin's lymphoma, this framework allows to determine, among the five considered methods, the one that provides results closest to the manual delineations set, performed by five experts [6]. In this purpose, data had to be collected.
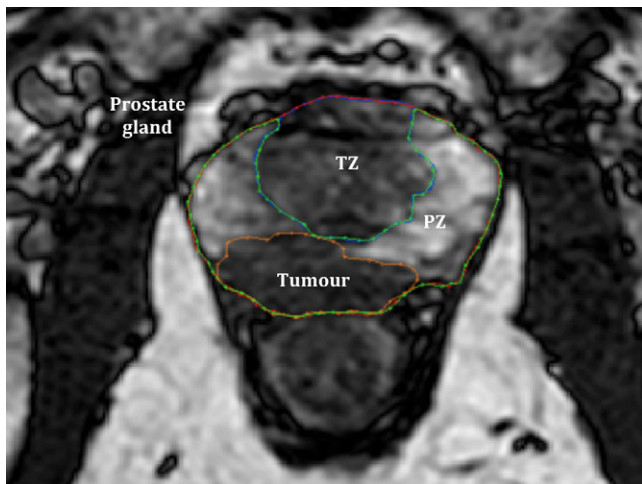

Fig. 1. T1W axial MR image of prostate with delineation of prostate gland, peripheral zone (PZ), transition zone (TZ) and tumour in the peripheral zone.
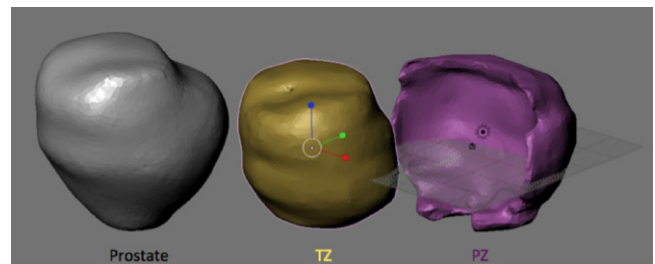

Fig. 2. An example of mesh files for the three structures: prostate, peripheral zone (PZ) and the transition zone (TZ) described as level sets and provided in the Object File Format.