INS-MOB

Informatics Monday Poster Discussions

Monday, Nov. 28 12:45PM - 1:15PM Room: IN Community, Learning Center

IN

AMA PRA Category 1 Credit ™: .50

FDA Discussions may include off-label uses.

Christopher R. Deible, MD, PhD, Pittsburgh, PA (*Moderator*) Nothing to Disclose

Sub-Events

IN210-SD-MOB1 Performance Assessment of Data-driven Imaging Biomarker for Screening Pulmonary Tuberculosis on Chest Radiographs

Station #1

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PURPOSE

The aim of the study was to investigate the performance of screening tuberculosis (TB) lesion based on data-driven imaging biomarker (DIB), which is an imaging biomarker that is derived from large-scale medical image data by using deep learning technology. Especially, we assessed DIB for TB screening in chest radiographs (DIB-TB) in various race groups and different scales of training sets.

METHOD AND MATERIALS

We constructed experiments on two different datasets which consist of 10,848 (7,020 for normal, 3,828 for TB) and 45,621 (22,202 for normal, 23,419 for TB) cases, respectively. The ground truth diagnosis results only include whether each case is TB or not. DIB-TB was trained based on deep convolutional neural networks. Two independent DIB-TBs trained based on two different datasets were used for demonstrating the impact of the number of training samples. In order to evaluate the performance of DIB-TB, we used three datasets; Shenzhen, Montgomery (public dataset) and in-house validation set (10% of the entire dataset was randomly selected for validation). Especially, two public datasets were used to show the robustness of DIB-TB in various race groups. Shenzhen dataset consists of 326 normal and 336 TB cases, and Montgomery dataset consists of 80 normal and 58 TB cases.

RESULTS

DIB-TB trained on the first (small-scale) dataset achieved viable TB screening performance; 0.964, 0.926, 0.884 in terms of AUC and 0.903, 0.837, 0.674 in terms of accuracy for in-house, Shenzhen, and Montgomery datasets, respectively. In DIB-TB trained on the second (large-scale) dataset, screening performance was significantly improved; 0.973, 0.963, 0.931 in AUC and 0.915, 0.894, 0.848 in accuracy for the same order. The best accuracy, sensitivity, specificity were 0.902 (at probability threshold 0.4), 0.863, 0.942 for Shenzhen set, and 0.855 (at probability threshold 0.45), 0.810, 0.863 for Montgomery set, respectively.

CONCLUSION

The screening performance of DIB-TB can be significantly improved as the number of training samples increases. Additionally, we showed that DIB-TB is robust against the various race groups; DIB-TB trained from the dataset with specific race group can be used for different races with high screening performance.

CLINICAL RELEVANCE/APPLICATION

DIB-TB based on a large-scale chest radiographs can significantly improve the performance of TB screening. And, it can be applied for other race groups.

IN219-SD-MOB2 A Path to Affordable 3D in Radiology - Applied 3d-printing and Low-cost Virtual Reality in a University Hospital Setting

Station #2

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PURPOSE

While radiologists are used to interpret images “by slice” and to communicate through a written report, it may not be the most powerful method to convey information to non-radiologists including patients. With the advent of new visualization tools, the presentation of medical imagery may return to the third dimension through virtual reality and 3D printing. An outline of a low threshold approach to bring medical imagery back into the true and virtual third dimension is presented.

METHOD AND MATERIALS

The basis of creating a 3d-model is a cross sectional imaging study (CT/MRI). Common radiology post-processing software is used to extract the intended 3D model by thresholding and segmentation. After export as STL-file, post-processing (smoothing, defect-filling and consistency checking) is performed in freely available software e.g. Blender, Meshlab or Meshmixer. 3d-models are then printed on standard commercially available fused filament fabrication (FFM) consumer 3D printers, ranging from 500-4000$. Virtual visualisation of the model is achieved by utilizing the identical 3D model file on a 3D web platform (sketchfab.com). This allows for a low cost virtual reality setup by using google cardboard, a $5-10 box housing lenses and a smartphone. The smart phone creates dynamic stereoscopic imagery on screen oriented by its sensors positional information.

RESULTS

The described workflow proved to be a feasible and robust way to create 3D models in a reasonable time frame with low financial investments of approx. $3500. The created 3D models were well received by referring physicians in particular pediatric cardiology, cranio-maxillofacial, vascular and cardiac surgery as well as urology. According to the referring physicians, 3D models facilitate surgical planning, understanding of complex pathology, communicating pathological findings to patients and teaching students or residents.

CONCLUSION

A robust and feasible workflow to bring medical images back into the virtual and true third dimension is demonstrated. The presented approach allows any radiology departement to perform "first steps" in this expanding technology with a low financial and organizational threshold.

CLINICAL RELEVANCE/APPLICATION

3D printing and virtual reality are becoming important ways to communicate image findings. Radiology needs to master this technology to maintain its leading role as a technology driven specialty.

IN220-SD-MOB3 Developing Multi-resolution Convolutional Neural Networks for Lung Nodule Segmentation

Station #3

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PURPOSE

To develop a data-driven approach for automated lung nodule segmentation in CT images to facilitate computer-aided diagnosis of lung cancer.

METHOD AND MATERIALS

Lung nodule segmentation in CT images remains challenging due to the fact that nodules can be attached to lung wall or vessel and various nodule sizes pose an additional challenge. We propose a framework utilizing convolutional neural networks (CNN) to distinguish lung nodule and healthy tissues. Our data-driven approach defines multi-resolution lung nodule patches by extracting 0.34 million patches centered on nodules (21x21, 45x45, and 65x65 pixel sizes) from coronal, median sagittal, and axial views. We train three CNN models separately corresponding to the three views to generate probability scores for pixel classification. We achieve the ultimate segmentation by applying a logistic regression to integrate probability outcomes obtained from three trained CNN models. Segmentation performance was evaluated on 893 lung nodule cases (450 for training and 443 for testing) from LIDC-IDRI dataset. We report segmentation accuracy on the testing set by comparing outcomes against ground-truth contours with Average Dice Score (ADS(%)) and Average Hausdorff Distance (AHD).

RESULTS

The proposed CNN approach achieved encouraging segmentation results (ADS=80.20%, AHD=3.83), outperforming conventional graph cut method (ADS=68.97%, AHD=7.78) on 443 testing nodules. In particular, we reported superior results for segmenting tumors attached to the lung wall (124 cases) with ADS 79.53% and AHD 4.31. We additionally showed outcomes given various tumor diameters (D). For the 350 nodules with D<12 mm, our CNN achieved ADS=79.30% and AHD=3.31. For the remaining 93 nodules with D>=12mm, the ADS is 83.59% and AHD is 5.83. Overall, our results revealed superior outcomes of segmenting nodules given a variety of lung nodule locations and sizes.

CONCLUSION

Developing computerized segmentation technique is a crucial step in computer-aided lung cancer diagnosis. We presented a data-driven CNN model for lung nodule segmentation that is able to deal with nodules attached to lung wall and nodules with various sizes.

CLINICAL RELEVANCE/APPLICATION

The proposed automated lung nodule segmentation holds promise to accelerate follow-up lung nodule CT diagnosis (e.g., survival, TNM staging) with growing number of lung nodule CT sequences.

IN221-SD-MOB4 A Manufacturer-independent Ultrasound Strain Elastography Module: Phantom and Clinical Study

Station #4

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PURPOSE

Ultrasound strain elastography has been widely used to assess tissue mechanical properties. We develop and assess a novel manufacturer-independent elastography ultrasound module that can be integrated with commercially available gray-scale ultrasound machines to introduce strain elastography using freehand quasi-static compression.

METHOD AND MATERIALS

Conventional grayscale ultrasound images were acquired from, at least, 10 ultrasound machines of 7 manufacturers. Cine-loops (n> 200) of breast elastography phantom were collected while applying freehand compression (1-5%) using the transducer. The phantom included solid masses two times stiffer than background. Video signals were acquired via a high-definition video capture device. Frame-to-frame displacements were calculated using a novel hierarchy recursive displacement tracking technique. Strain was calculated as displacement spatial derivative, and was then superimposed on gray-scale images to provide both anatomical and mechanical information. Under Internal Review Board and consented forms, cine-loops of female breasts (n=27) were acquired while applying freehand compression. 14 women underwent double readings and their BI-RADS was classified.

RESULTS

Using the module, strain elastography was reconstructed successfully form all machines. The stiffer phantom masses exhibited low strain compared to the background tissue-mimicking material with a strain ratio of 2.52±0.29 between background and harder masses. A strain signal to noise ratio (SNR) of 7.50±3.01 and contrast to noise ratio (CNR) of 5.21 ± 1.58 were measured. Elastograms reconstructed using the module showed good match with those of a commercial machine. Strain images were reconstructed successfully for clinical breast data and masses were observed, however, lower values of SNR and CNR were measured.

CONCLUSION

This study showed the feasibility of a vendor-independent strain elastography module via both phantom and clinical data. Quantitative strain values measured using the module integrated with 10 different ultrasound machines exhibited good match with known phantom mechanical stiffness. This add-on module may provide a cost-effective and standardized ultrasound strain elastography complementary tool for the diagnosing and monitoring of tumors.

CLINICAL RELEVANCE/APPLICATION

This vendor-independent elastography add-on module can be integrated with gray-scale ultrasound machines to assess the mechanical tissue changes such as breast and thyroid tumors.

IN222-SD-MOB5 Open-source and Commercial Software Applications for Clinical 3D Printing

Station #5

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CONCLUSION

Common to all applications related to 3D visualization is the need for post-processing of image data. 3D printing introduces new geometric constraints to existing clinical workflows, and familiarity with available CAD tools is prerequisite to successful integration of this technology into patient care.

Background

3D modeling for 3D printing is intrinsically different from clinical post-processing such as surface rendered reconstructions, and introduces new model constraints - most notably the concept of manifold geometry. Other novel and important characteristics include face normals, compactness, and polygon counts. These play a critical role in fabrication of a patient model. Expertise in other fields routinely address these needs with CAD software tools, and we have an opportunity to develop analogous medical imager-specific workflows for 3D printing. As the full library of open-source and commercial options may not be widely known, this work seeks to demonstrate how myriad combinations of such tools may be used to achieve the common aim of translating medical image data into a physical object.

Evaluation

We limit this work to post-processing of CT image data into a printable 3D model. This invariably includes initial review of images, threshold segmentation, and modeling in a CAD environment.

Discussion

Several DICOM viewers include tools for post-processing and threshold segmentation. Label maps are generated according to attenuation parameters and/or region seeds, and used to triangulate polygons into a surface mesh. This must satisfy manifold geometric requirements to be represented in physical space. Non-manifold geometries commonly include edges with multiple adjoining faces or result from self-intersecting faces, and are limited to mathematical representation. Models should also satisfy the requirement of compactness, referring to a closed Euclidean space, violations of which commonly include holes or flipped normals. These model characteristics are addressed efficiently in a CAD environment, with automated and semi-automated tools. The final surface mesh representing the anatomy of interest is then translated into printing instructions, often specific to each 3D printing technology and sometimes proprietary.

IN223-SD-MOB6 PET/CT In Lung Cancer: An Automated Imaging Tool for Decision Support

Station #6

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PURPOSE

Lung cancer (LC) accounts for 12.7% of the world's total cancer incidence. PET/CT plays a central role in LC diagnosis and staging. Powerful quantitative techniques e.g. CT texture analysis (CTTA) can enhance the diagnostic utility of PET/CT by providing information on tumor aggression & resistance. Such techniques however cannot be used in busy clinics where the analysis remains time-consuming & prone to user error. This preliminary study assesses the performance of an automated PET/CT analysis in lung cancer and compare against experienced imaging reporting.

METHOD AND MATERIALS

Patients: 44 consecutive patients (age:68.7+/-10.3 years, 32 males) with LC who underwent FDG-PET/CT (GE Discovery) were analyzed retrospectively. Average follow up was 22.7+/-16.1 months. Clinical stage information was available in 42 patients (I:1, II:9, III:28, IV:4). Reader analysis: Two clinically qualified readers analyzed the patients independently; manually segmenting the tumor on the CT slice corresponding to the most avid lesion on PET. Unenhanced CTTA using the filtration-histogram technique (TexRAD Ltd, www.texrad.com, part of Feedback Plc, Cambridge, UK) was employed. Automated analysis: Automated algorithm uses both CT and PET to auto-segment the lung and lesion. Statistics: 1) Inter-user agreement for ROI area was assessed with Bland-Altman (BA) statistics & Intra-class correlation (ICC). 2) Algorithm segmentation accuracy (ROI area) against ground-truth (mean reader area) was assessed with BA statistics. 3) Survival analysis was performed using Kaplan-Meier analysis log-rank test.

RESULTS

Automated approach was successful in 41/44 (93%). 1) Inter-reader agreement for ROI area revealed a mean difference of 372mm2, 95% limits of agreement (LoA) of 2671mm2 across a data range of 328mm2 to 4735mm2 (ICC=0.32). 2) ROI area of algorithm and ground-truth demonstrated a mean difference of 11mm2, 95% LoA of 1030 mm2 across a data range of 433mm2 to 4426mm2 (ICC=0.85). 3) CTTA from automated analysis predicted survival (Kurtosis,p=0.028).

CONCLUSION

The automated approach requires no user intervention and represents a repeatable method for lung identification, lesion segmentation and texture-analysis on PET/CT in lung cancer.

CLINICAL RELEVANCE/APPLICATION

Automated PET/CT lung cancer tool may standardize clinical performance whilst allowing access to quantitative texture analysis to improve prognostication and fit within clinical workflow.

IN111-ED-MOB7 Deep Learning: A Primer for Radiologists

Station #7

Awards
Cum Laude
Identified for RadioGraphics

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An Tang, MD, Montreal, QC (*Abstract Co-Author*) Advisory Board, Imagia Cybernetics Inc

TEACHING POINTS

1. To review the key concepts of deep convolutional neural networks (DCNN), an artificial intelligence technique2. To illustrate applications of deep learning techniques for lesion detection, classification, and monitoring3. To discuss the potential benefits of computer assisted diagnosis with deep learning techniques

TABLE OF CONTENTS/OUTLINE

-Clinical applications: lesion detection, segmentation, classification, image interpretation, prioritization and monitoring.-Classification of computer vision techniques: deformable models (active contour, level-set, statistical shape models), graph-cut, machine learning (support vector machines, random forest algorithms, deep learning).-Comparison: advantages and limitations of each computer vision technique.-Illustration of key ideas behind neural networks: biological inspiration, artificial neural networks, hidden layers, learning process.-Illustration of key concepts of deep learning: multiple stacked layers, convolution applied to images, pooling, activation functions.-Technical requirements: supervised (labelled), semi-supervised and unsupervised learning; training dataset; hardware (GPU).-Pitfalls: size of training dataset, quality of ground truth, spectrum of disease, architecture of neural network.-Future directions: natural language processing, caption generation.

IN024-EC-MOB Exact Mapping of Medical Images Inside a Patient Body Using Three-Dimensional Printing Surgical Guides: Evaluation for Guiding Breast Cancer Margin

Custom Application Computer Demonstration

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CONCLUSION

The surgical guide for breast cancer resection using 3DP could be used for more exact and conserving surgery. This quantitative mapping of MRI information into a patient body lets surgeons securing tumors' surgical margin, and promises shorter operation time and convenience as well.

FIGURE

http://abstract.rsna.org/uploads/2016/16012109/16012109_elln.jpg

Background

Partial resection of breast cancer recently has been achieved even though a tumor size is relatively small. To identify the cancer position, a method of clip or h-wire with ultrasonography has been usually provided, but it causes patient's pain as well as cost. In addition, no exact guidance for cancer margin makes surgeons determine relatively larger surgical exclusion. However, it would be subjective. Therefore, the objective of this study is developing a patient-specific three-dimensional printing (3DP) surgical guide enabling quantitatively to map cancer margin on a patient body and evaluating its clinical usage.

Evaluation

From MRI images, morphological shapes of breasts and tumors were modelled (Fig. 1A and 1B). The surgical margin including safety area was designed, and then the margin was projected onto the surgical guiding surface, fitting to the breast surface. Here, morphology of breast and nipple became landmarks for tailored guidance. We proposed two types of surgical guides including a skin marking type (Fig. 1C and fig. 2A) to enable drawing a line on skin and a hybrid type (Fig. 2B) providing a guide line on skin and columns for guiding dye-injections into tissue, which had each different lengths for needle targeting on the exact surgical margin in-depth. The prepared models was saved in STL format and then exported to a 3D printer. The manufactured surgical guide was used in operation room after the sterilization.

Discussion

Four patients enrolled from December 2015 to January 2016. Median age was 46.5 years. After surgery using the developed surgical guide, the distances from the tumor to the margins were measured. Pathological complete remission occurred in two patients. All patients had clear resection margins (Fig 2C). The median distance from the tumor to the margins was 1.2 cm.

IN025-EC-MOB Web Browser Based Cloud System for Generating and Sharing 3D Models for 3D Printing with Workflow Management, Hybrid Visualization and Mobile Interfaces in Hospital

Custom Application Computer Demonstration

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CONCLUSION

We developed web browser based cloud system for generating and sharing 3D models for 3D printing for collaborations among image processing specialists, radiographer, radiologist, physician, patients, and operation room staffs

FIGURE

http://abstract.rsna.org/uploads/2016/16015490/16015490_rsbl.jpg

Background

Three dimensional modeling for 3D printing needs very complicated communication workflow and collaborations among image processing specialists, radiographer, radiologist, physician, patients, and operation room staffs. Especially, 3D visualization of models is not easy in conventional communication environment including e-mail, chatting program, etc. Therefore, it is very important to develop web browser based cloud system from production to sharing of 3D models for 3D printing.

Evaluation

For workflow of 3D modelling and printing, many collaborators with diverse specialties including image processing specialists, radiographer, radiologist, physician, patients, and operation room staffs needs to be involved and collaborated in synchronous and/or asynchronous manner. For effective communication and collaboration in clinical environment, a platform to support and manage the 3D model data workflow is needed with new technical features including web based cloud system, hybrid rendering (surface and volume rendering) and mobile interface. In addition, advanced techniques for semi-automatic image segmentation including graph cut and volume sculpt and mutli-atlas based segmentation. For 3D modelling with different modalities including MRI, multiphase CT, etc, various registrations including level-set based, optical flow based, b-spline based registrations were implemented. Workflow including 3D models generated by image processing specialists and radiographer, confirmed by radiologist and physician, shared with patient and operation room staffs is flexibly defined and managed by this could system. Measurements (x-axis, y-axis, a-axis, volume) of eight patient-specific kidneys by this system are 61.87±4.56mm, 120.64±9.03 mm, 55.38±10.62 mm, 226.45±67.95 cm3, respectively.

Discussion

For communication and collaborations, there should be a platform to support and manage the 3D model data workflow and collaboration in the real clinical environment in effective manner.