Hypothesis

Deep learning is a robust approach for the view identification in x-ray images. In this work, we validated this hypothesis to automatically label X-ray images based on standard views of acquisition: frontal which include posterior-anterior (PA) and anterior-posterior (AP) and left and right lateral (LL and RL).

Introduction

Despite advances in medical imaging modalities, chest digital x-ray images still serve as a crucial diagnosis imaging tool for detection and screening of lung and heart abnormalities. Typically, x-ray images are taken from four standard views: frontal which include posterior-anterior (PA) and anterior-posterior (AP) and left and right lateral (RL and LL). Besides the image content, medical images (DICOM) are accompanied by meta-data which contains essential information required for proper interpretation of the image data such as image dimensions, pixel/voxel size, anatomy of interest, etc. Typically, DICOM meta-data fields are dedicated to identify the view: AP, PA, LL, and RL; however, such information is typically manually entered by the technologist at the time of imaging and therefore, it quite frequently occurs that such information is missing in the meta-data or prone to human errors which can reach even 50% levels [8]. Based on the image content itself, a human naked eye can distinguish between views being frontal (PA AP) or lateral (LL RL); however, automatic distinction of different views from one another could be challenging due to variation in noise, patient size and field of view and body symmetry. Automatic view detection is necessary for correct implementation of artificial intelligence algorithms (computer-aided diagnosis, etc.) when large numbers of images are processed and visual inspection view identification is not practical.

There has been some previous efforts towards automatic view detection in x-ray images [1-7], the most recent one proposed by Xue et al. [8] utilizes image-based features for classification of chest x-ray images based on the view. Authors demonstrated promising results using a large publically available database of chest x-ray images [9].

Method

In this work, we present a deep learning-based (DL) approach for unsupervised classification of chest x-ray images based on the view into three categories: frontal, left and right (Figure 1). In the current implementation, we do not distinguished between AP and PA and classify those as frontal. We do distinguished between left and right lateral views. However, we treat RL and LL flipped vertically as right view and LL and RL flipped vertically as left view. We will investigate DL methods for distinguishing between flipped and unflipped views in the future work.
We constructed a deep neural network as schematically presented in Figure 2. It consisted of two convolutional and two pooling layers followed by a densely connected layer. We used softmax three-classes loss (Figure 2). The caffe framework [11] was used for the implementation.

The proposed tool was tested on the same dataset as used in [8] for comparison available for public use. The NLM Indiana chest radiographs dataset consists of 7,462 chest x-rays from different views and the corresponding 3,955 radiology reports (3,995 subjects). The entire dataset including both DICOM meta-data as well as radiology reports were fully anonymized [10]. The ground truth for views (labels corresponding to frontal, left, and right views) were generated by the visual inspection of individual images. Images of the original size of up to 2096 by 2096 were reduced to exactly 128 by 128 pixels. Aspect was not preserved.

By the visual inspection, we identified 3822 frontal, 3434 left, and 206 right views in the original dataset. Because of the significant imbalance in the sizes of the original dataset, we augmented sizes of left and right classes by adding randomly selected members of original classes. The total size of the dataset used for training and validation was 3822, 3640, 3640 for front, left, and right classes, respectively.

Order of images in each group was randomized and ten-fold validation was performed with 3334 images used for training and 334 images used for testing.
Results

We found that loss is rapidly minimized using stochastic gradient decent algorithm (Figure 3). Table 1 presents results with comparison of the performance of the DL with previously published results using the same data set. In general, we demonstrated a near perfect performance (accuracy near 1 for 10-fold validation) and comparable, if not better, than feature-based machine learning [8].

Table 1

<table>
<thead>
<tr>
<th>Method</th>
<th># of features used</th>
<th>Accuracy 10-fold valid.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Image profile (IP)¹</td>
<td>400¹</td>
<td>98.4%¹</td>
</tr>
<tr>
<td>Body size ratio (BSR)¹</td>
<td>1¹</td>
<td>90.5%¹</td>
</tr>
<tr>
<td>CBSF¹</td>
<td>196¹</td>
<td>99.5%¹</td>
</tr>
<tr>
<td>PHOG¹</td>
<td>680¹</td>
<td>99.7%¹</td>
</tr>
<tr>
<td>IP+BSR+CBSF+PHOG¹</td>
<td>1277¹</td>
<td>99.9%¹</td>
</tr>
<tr>
<td>Deep learning (DL)</td>
<td>Not applicable</td>
<td>99.99%</td>
</tr>
</tbody>
</table>

Table 1. Comparison of accuracy of various methods for x-ray view classification. ¹Results are reproduced from Xue et al. [8]. The same data sets as in [8] were used for DL.
Discussion

Deep learning has gained popularity in recent years and is applied in various areas of research and industrial applications. The main benefit of using DL is that the features used for various classification tasks do not have to be defined a priori which in principle reduces the risk of suboptimal feature definition for a given machine-learning task. In this abstract, we demonstrated a use case where DL allows us to accurately classify x-ray views taking as the input the raw image data. Although we achieve excellent accuracy, more extensive validation of the algorithm is needed using different data sets. Current implementation of the algorithm neither distinguishes between AP and PA views of the frontal, nor between left lateral and flipped right lateral, and right lateral and flipped left lateral views. Application of DL to this task will be investigated in the future.

Conclusions

Deep learning approach is a promising tool that can be used for automatic view identification in x-ray images.

References


Keywords

radiology, deep learning, chest x-ray