Identification and retrieval of prostate cancer cases using a content-based search tool

Sebastian Otálora[1], Dr Manfredo Atzori[1], Roger Schaer[1], Dr Mats Andersson[2], Dr Kristian Eurén[2], Martin Hedlund[2], Lena Kajland Wilén[2], Prof Henning Müller[1]
[1]University Of Applied Sciences Western Switzerland, [2]ContextVision AB

E-mail of the corresponding author: manfredo.atzori@hevs.ch

Abstract: In recent years, large amounts of digital histopathology images have become available. Such images can be useful for pathologists, however, searching for specific cases and similarities within them is not straightforward. In this work, we present a content-based retrieval system and a scale detection method that can allow browsing in heterogeneous prostate histopathology datasets. The system is based on state-of-the-art deep convolutional learning networks [1] and handcrafted features. The system allows to retrieve regions of prostate images that are visually similar to manually delineated regions of interest at specific magnification levels. Several image features were tested and compared, showing that a properly tuned retrieval system can enhance the practice of pathologists.

Background: Large amounts of histopathology images have become available in digital form over the past years. Such databases allow to algorithmically analyse the images and also makes them available for visual image retrieval. However, retrieving histopathology images from varied sources, such as the literature and teaching files can be difficult due to their heterogeneity in magnification, color and, sometimes, a lack of metadata. In this work, we present a content-based retrieval system and a scale detection method that can allow browsing in heterogeneous histopathology datasets.

Methods: An annotation tool integrates the visual image retrieval system for digital pathology [1], allowing to perform the tests and to visually evaluate the results. The extracted image features as well as the detection of the scale are based from finetuned state-of-the-art deep convolutional learning networks [2] and handcrafted texture, shape, and color features. The dataset includes a proprietary set of whole slide images and histopathology images automatically extracted from the biomedical open access literature of Pub Med Central. The total training time for the deep learning networks did not exceed 4 hours, using a modern graphics processor unit.

Data: The used data include 110 whole slide images of prostate biopsies and their respective indexed features of small regions at 5, 10, 20 and 40X. In total more than 100'000 regions where indexed and used for training of the deep learning network. There where local annotations for some of the images, and the size of the regions indexed is of 224x224 pixels.

Results: The system allows to retrieve regions of prostate images that are visually similar to manually delineated regions of interest at specific magnification levels.
The quantitative retrieval performance of both types of visual features extracted is depicted in Figure 2. The main observation is that the deep learning based features have better performance at higher magnifications, i.e., at 20 and 40X, this could be partly due to the fact that the number of patches used for this magnifications was slightly bigger than for lower magnifications. This also suggests that the performance of the system could be better if more images are added to the training of the deep learning networks. Another observation is that the precision of both types of features is similar when there are not many retrieved results, but in general, the deep features have better performance when more results are retrieved.
Scale detection allows to identify the scale of the images and define adapted features for retrieval and classification even if the magnification level is unknown.

Visual evaluation of the results was performed in two different ways as shown in Figure 1 a and b. First, by searching for similar data within the same image. The size of a whole slide image (WSI) can easily be pixels, and regions of interest can be small (e.g. 103-105 pixels). Thus, searching a WSI to find areas that are similar to a specific region of interest can be time-consuming for the pathologist. The system retrieves the most similar regions within the image similar to the defined region of interest within the image and provide them to the user as a convenient side-by-side list, this helps for pathologist to automatically look for missing annotated areas in the whole slide image. The second way to obtain relevant information is by comparing the suspicious area to the similar images that are present in the open access literature, i.e., pathology journals. In the latter case, it is possible to launch a multimodal query by combining an image region and relevant text. This system allows to refine the amount and quality of images retrieved.
A short video demonstration of the system is available at https://youtu.be/uwIezxabiaw .

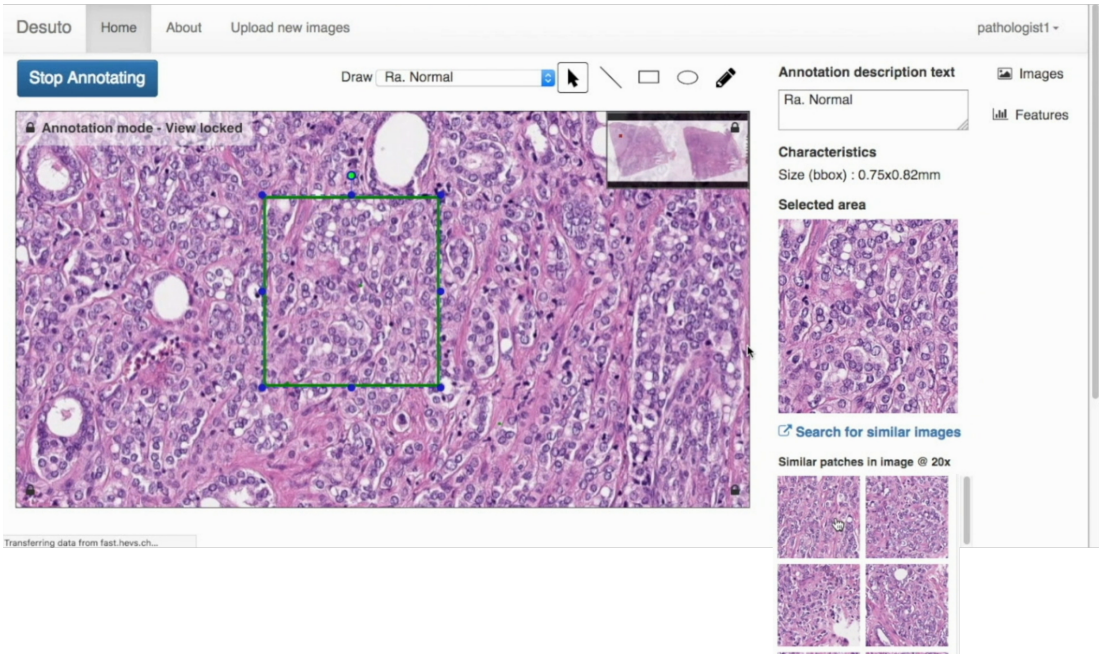
Conclusions: We compared different scale-based features for the identification and retrieval of similar prostate cancer regions of interest. The features allow searching for similar areas at specific scales and will be combined with a scale detection system. A visual histopathology retrieval system can enhance the practice of pathologists allowing them to easily retrieve similar regions in mage or similar cases in proprietary datasets. The scale detection improve the retrieval performance on heterogeneous datasets, thus allowing pathologists to retrieve images from scientific publications, teaching files and books. A quantitative evaluation of the performance of the system was performed. The evaluation of the system shows that even though some improvements must be made, the features ability to retrieve relevant areas within the same image and the scientific literature, opens the possibilities to assist pathologists in their daily work and research duties using this kind of systems.

Figure legends:
Figure 1: Retrieved similar regions in a) the same whole side image and b) Images from PubMed Central journals.
Figure 2: Precision-Recall graph of the retrieval performance using visual features extracted with the DenseNet architecture (orange line) and the color and edge directivity descriptor features (blue line) in four magnification levels. The DenseNet features are systematically leading to slightly higher results, especially for higher magnification levels (20 and 40X).

References:
[1] Roger Schaer, Sebastian Otalora, Oscar Jimenez del Toro, Manfredo Atzori, and Henning Mueller. Deep learning based retrieval system for gigapixel histopathology cases and open access literature. Journal of pathology informatics, 10:19, 2019.
[2] Gao Huang, Zhuang Liu, Laurens van der Maaten, Kilian Q. Weinberger. "Densely connected convolutional networks. Proceedings of the IEEE conference on computer vision and pattern recognition. Vol. 1. No. 2. 2017.

Figure 1

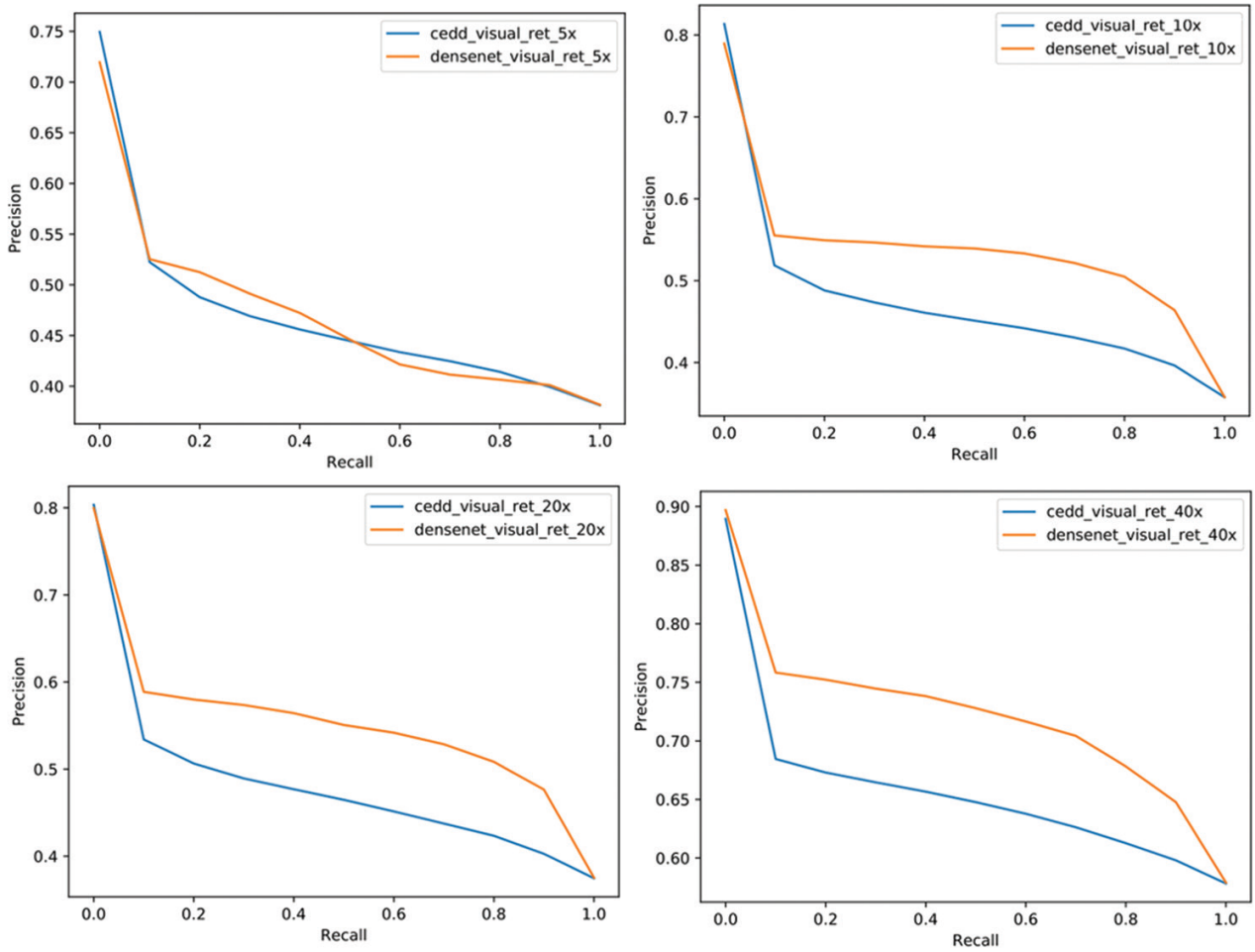
a


Desuto
Home
About
Upload new images
pathologist1
Stop Annotating
Draw
Ra. Normal
Annotation mode - View locked
Annotation description text
Ra. Normal
Images
Features
Characteristics
Size (bbox) : 0.75x0.82mm
Selected area
Search for similar images
Similar patches in image @ 20x
Transferring data from fast.hevs.ch...

b


Stop Annotating
Draw
Ra. Normal
Annotation description text
Features
Desuto
Relevant Text
prostate gleason 4
Relevant Images
Select feature
PubMed Central
CEDD
Read fast.hevs.ch

Figure 2


cedd_visual_ret_5x
densenet_visual_ret_5x
Precision
Recall
cedd_visual_ret_10x
densenet_visual_ret_10x
Precision
Recall
cedd_visual_ret_20x
densenet_visual_ret_20x
Precision
Recall
cedd_visual_ret_40x
densenet_visual_ret_40x
Precision
Recall