LSTM-U-net for the robust segmentation of veins in ultrasound sequences

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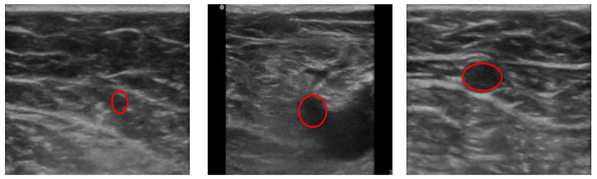
Introduction

- High Focused Ultrasound (HIFU) treatment for varicose veins is a non-invasive technique to ablate insufficient veins
- The therapy is monitored by diagnostic Ultrasound B-mode imaging
- The course of the targeted vein must be followed during the procedure in order to ablate the entire vessel



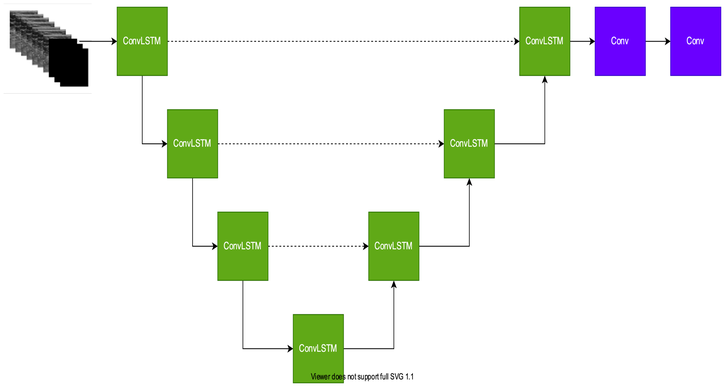


Figure 3. Diagram of the proposed LSTM-U-net architecture

Methods

We propose a LSTM-U-net architecture which is able to track and segment the vein in real-time in diagnostic ultrasound image series. We conducted multiple experiments:

Experiment 1: Prediction of future frames
- Trained the model on ultrasound time series while replacing the last three frames with zeros
- Skipped frames randomly to account for rapid changes of the veins appearance

Experiment 2: Tracking of structures outside of the image edges on whole and on cropped image series
- Trained the model on images series in which the edges are replaced by zeros (See **Figure 2.**)
- Trained the model on patches of images series in which the edges are replaced by zeros

Experiment 3: Evaluation of usage of ConvLSTM layers in the U-net architecture
- Implemented two architectures derived from the LSTM-U-net
- The „Encoder“ architecture in which the ConvLSTM layers in the decoder part were replaced by regular 2D convolution layers
- The „Decoder“ architecture, which employs ConvLSTM layers in the decoder part and regular 2D convolution layers in the encoder
- Evaluated all three architectures with the same training setup (See **Table 1.**)

Architecture	Dice Coefficient	Epochs until conergence	Trainable Parameters
Both	0.959	73	1,859,658
Encoder	0.94	46	1,520,634
Decoder	0.90	40	676,650

Table 1. Comparison of different architectures from **Experiment 3**

Results

- Model based on **LSTM-U-net** architecture is well suited for the **robust tracking of veins** in ultrasound series in **real-time**
- ConvLSTM layers are more important in the encoder part of a U-net in term of DSC and can be omitted in the decoder in order to make the model smaller for a little reduction in the DSC

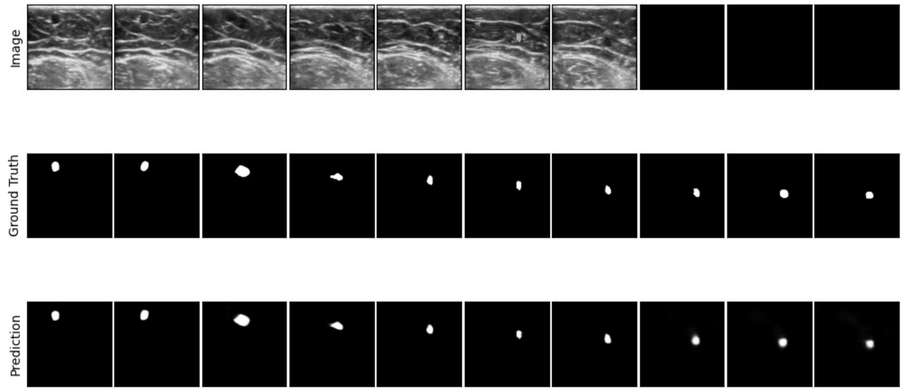


Figure 1. Result of Experiment 1: Segmentation of the vein over several time steps with predicted position for the last three time steps

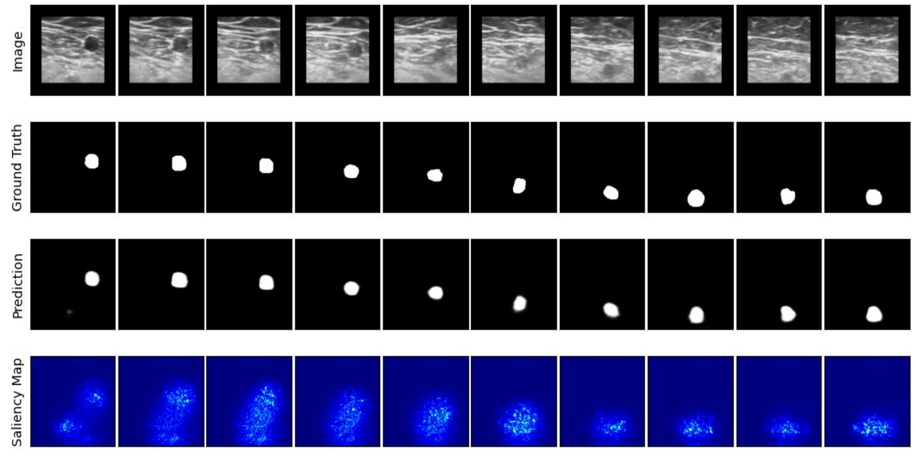


Figure 2. Result of Experiment 2: Segmentation of the vein if it moves outside of the visible image

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