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"Detecting Venous Disorders via Near-Infrared Imaging: Observation of Varicose Vein Development"

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About the Presenter

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- Research Interests:
 1. Virtual Reality Environments, Computer Graphics, Digital Image Processing.
 2. Parallel Computing, Quantum Computing.

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Introduction

- **Medical imaging devices** are one of **the primary auxiliary methods** used in hospitals to diagnose different diseases; [1]-[3]
 - ✓ **X-Ray** device, which emits harmful rays (ionizing radiation) to the body, is predominantly used in the imaging of bone tissue and abdominal diseases,
 - ✓ **Computed Tomography** is used for imaging both bone tissue and internal organs,
 - ✓ **Magnetic Resonance** Imaging provides imaging of tissues with magnetic waves,
 - ✓ **Ultrasound** uses high-frequency sound waves for imaging.

Introduction

- **Problem definition;**
 - ✓ **Late detection** of diseases,
 - ✓ The habit of going to the doctor **after the disease occurs**,
 - ✓ **Neglect** routine controls,
 - ✓ Triggering other diseases by the imaging devices that work **with harmful rays**,

- ✓ Harmless alternatives to detect some diseases early: **vascular (varicose) disease**.

Introduction

- **Vein imaging; [1][2]**

- ✓ Computed Tomography,
- ✓ Magnetic Resonance,
- ✓ Ultrasound device,

- ✓ **Near-infrared light,**

- varicose veins are not easily visible to the naked eye, so near infrared light is used to visualize these veins [21].

Introduction

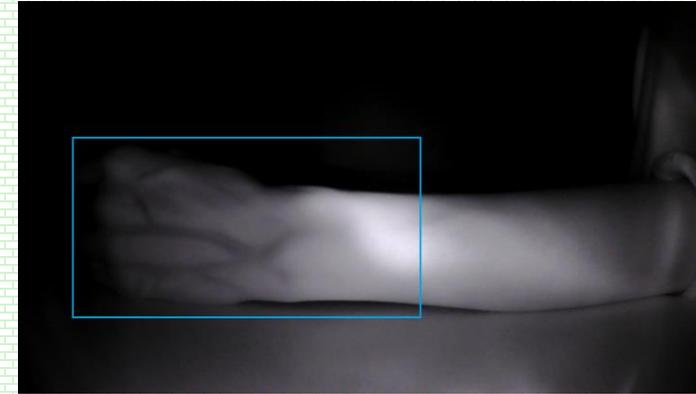
- **The visualization of the superficial veins;**
 - ✓ **Near infrared light source,**
 - ✓ **Near infrared camera,**
 - ✓ **Digital image processing filters** (the edges of the veins can be sharpened, only the relevant vein patterns can be revealed by eliminating the surrounding tissues or the noise in the image can be removed),
 - ✓ **Deep learning techniques** (classification or object detection/recognition).

Basics of the Study

- The proposed system's;
 - ✓ **Hardware** (the light source, LED and camera) and **digital image processing** (the extraction of vein patterns) parts were explained in [10],
 - ✓ **Classification** (convolutional neural networks), **object recognition** (narrowing detections using the YOLOv3 object detection algorithm with a single class as stenosis_vein) and **indirect augmented reality** (video-based content) parts were explained in [11].
- The **vein narrowing detection system** was retrained in this study to monitor **the vein enlargement**.

Vein Enlargement Detection: Near-Infrared Imaging

- Near infrared raw image of superficial veins on hand.



- Region of interest, containing only the veins to be examined.

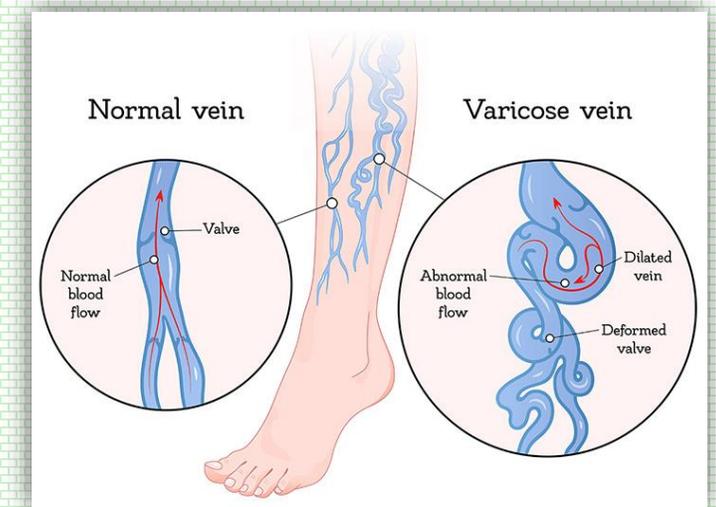


- Vein patterns obtained by digital image processing.



Vein Enlargement Detection: Chronic Venous Disorders and Stages

- **Chronic Venous Disorders (CVDs)** affecting millions of people worldwide [16][17],
- Risk factors: **heredity, lifestyle, gain** or **hormones** can lead to venous disorders such as vein enlargement; [18][19]
 - ✓ When the valves of the superficial veins do not work properly, blood accumulations occur, resulting in varicose veins [13][14],
 - ✓ Varicose veins can be encountered in every part of the body [15].



American Venous Forum. (Last Accessed: 18.06.2022)
<https://www.venousforum.org/patients/what-is-vein-disease/what-is-chronic-venous-disease/>

Vein Enlargement Detection: Chronic Venous Disorders and Stages

- **CVDs' clinical stages are defined by the CEAP (Clinical, Etiological, Anatomical and Pathophysiological [16]) classification system; [17][20]**
 - ✓ C0 (no visible signs of venous diseases),
 - ✓ C1 (visible veins, telangiectasia/spider veins),
 - ✓ C2 (varicose veins),
 - ✓ C3 (swelling/edema),
 - ✓ C4 (changes to skin quality),
 - ✓ C5 (healed ulceration),
 - ✓ C6 (active ulceration).



C. Mok, "Advanced Treatment Guides: Cure Your Leg Pain For Good", 2019. (Last Accessed: 18.06.2022)
<https://www.alluremedical.com/blog/varicose-veins/classification-venous-disease/>

Vein Enlargement Detection: Chronic Venous Disorders and Stages

- **CVD;**
 - ✓ **overlooked** in its early stages [16],
 - ✓ can be alleviated with the **support of lifestyle changes** [17][19].

- The incidence of vascular disorders in adults is 59% for **telangiectasia (spider) vein** and 14% for **varicose vein** [17].

Vein Enlargement Detection: YOLOv3

- In this study, the superficial vein surveillance system was used for the trials of the **YOLOv3** algorithm, which was re-trained to detect CVD;
 - ✓ **C1 (telangiectasia/spider veins)** and,
 - ✓ **C2 (varicose veins)** stages.



C. Mok, "Advanced Treatment Guides: Cure Your Leg Pain For Good", 2019. (Last Accessed: 18.06.2022)
<https://www.alluremedical.com/blog/varicose-veins/classification-venous-disease/>

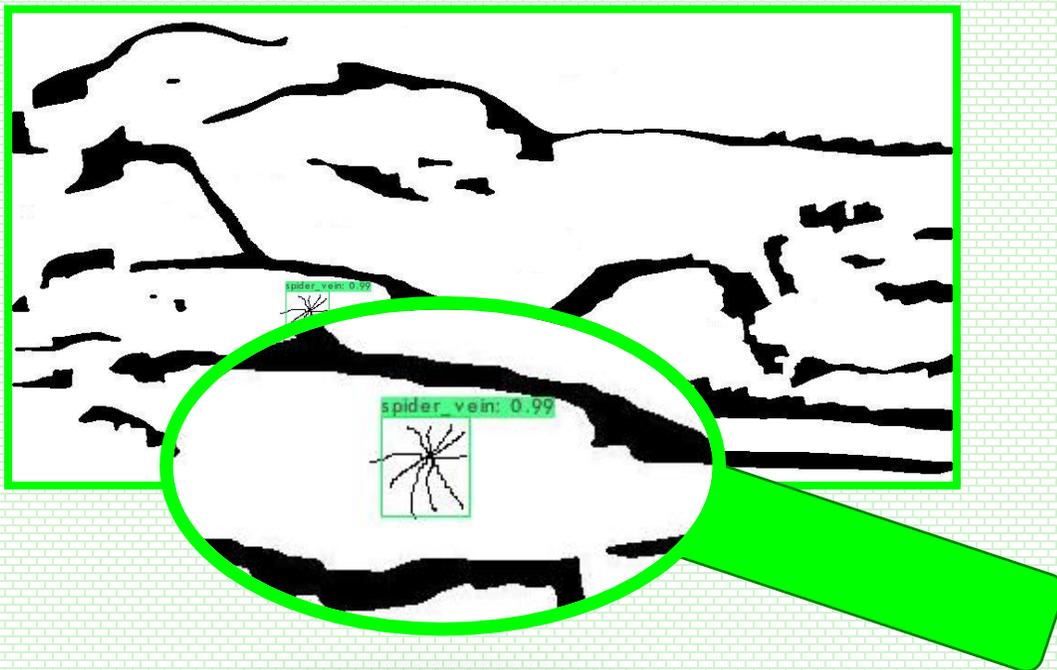
Vein Enlargement Detection: YOLOv3

- **YOLOv3;**
 - ✓ a deep learning algorithm,
 - ✓ object detection (training can be performed for multiple objects),
 - ✓ used for CVD detection in vein patterns obtained by image processing steps,
 - ✓ the system was **retrained** in this study to detect **CVD progression** using two separate classes;
 - **spider_vein** and,
 - **varicose_vein**.

Vein Enlargement Detection: YOLOv3

- Artificial spider_vein and varicose_vein patterns;

0.99 confidence valued result for spider_vein class.



0.90 confidence valued result for varicose_vein class.



Vein Enlargement Detection: YOLOv3

- The developed system can detect CVD patterns in **C1** and **C2** stages with;
 - ✓ **Accuracy Rate:** (1)
 - ✓ **Misclassification Rate:** (0)
 - ✓ **Precision:** (1)
 - ✓ **Prevalence:** (0.5)
 - ✓ **F-Score:** (1)

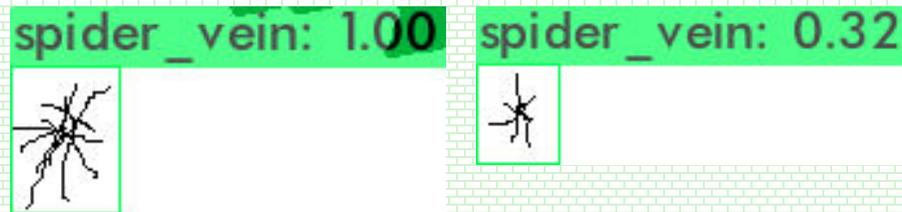
n=300		Predicted Class	
		Positive (spider_vein)	Negative (varicose_vein)
Actual Class	Positive (spider_vein)	True Positive=150	False Negative=0
	Negative (varicose_vein)	False Positive=0	True Negative=150

The confusion matrix of YOLOv3 algorithm results obtained with spider_vein and varicose_vein classes.

Vein Enlargement Detection: YOLOv3

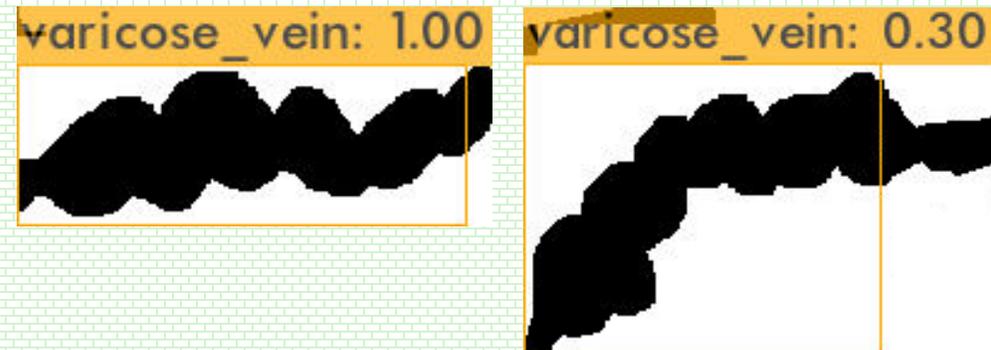
- The YOLOv3 algorithm had a **lower confidence value** for some patterns;

Situation-1



Artificial spider_vein patterns shown in accordance with their actual dimensions.

Situation-2



Artificial spider_vein patterns shown in accordance with their actual dimensions.

* **training dataset patterns:** mostly linear line patterns were used.

* **test dataset patterns :** linear line, U-shaped, twisted.

Conclusion

- ✓ superficial vein narrowing surveillance system, could be **expanded to detect vein enlargement**,
- ✓ YOLOv3 algorithm was used to **detect CVD patterns**,
- ✓ **confidence values of 0.90 and above** were achieved in object detection,
- ✓ development of CVD can be followed within the scope of **pre-diagnosis**,
- ✓ start the **treatment without delay**.

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