Automating a Diagnostic Ultrasound Vein Imaging Exam

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Problem/Goal

- Ultrasound imaging is performed manually on a daily basis to image nerves and veins. There are various variables that can affect the quality of the image.
- With safety and quality in mind, we want to study how to eliminate these variables as much as possible by incorporating robots into the ultrasound diagnosis process.
- We integrated a collaborative robot with a portable ultrasound machine and obtained the basic information needed for the automation of vascular imaging, using the brachial vein as an example.

Devices

Collaborative robot
- Safe to use alongside humans
- Easily programmable
- Universal Robot (UR3, Odense, Denmark)

Force sensor
- It measures the normal force applied to an object
- Robotous: (RFT76-HA01, Korea)

Ultrasound machine
- Uses high-frequency ultrasound to create high-resolution images of structures near the body surface.
- Ideal for vascular imaging (evaluate blood vessels)
- SonoSite (MicroMaxx ultrasound, Bothell WA)

Experiment #1

Amount of pressure applied to a human arm at different levels of probe displacement (mm)
Measured variables:
- Force and Pressure

Changed variables:
- Probe indentation (1-4 mm)
- Probe angle 90 degree

Experiment #2 (color parameter)

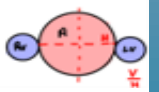
Measured variables: Color Doppler
- This experiment was subjective, so we created a scale to base the doppler images.

Rating	Picture	Description
5 Highest	5	Full color in both veins and artery
4	4	some color is missing For example the artery is red but the veins are colorless or vice versa
3	3	Mixed colors Artery has both red and blue when there should only be red
2	2	Colors of veins and arteries are flipped Based on the direction the transducer is held the artery should be red and the veins should be blue
1 lowest	1	No color in both veins or artery

Changed variables:
- Probe indentation (1-4 mm)
- Probe title angle 30, 60, 90 degrees

Experiment #3 (shape parameter)

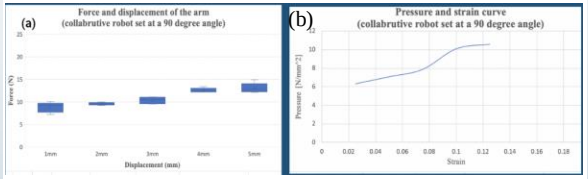
Measured variable:
- The ratio of the vertical and horizontal lengths of the blood vessels (veins and artery).



Changed variables:
- Same as experiment 2

Results

Experiments #1



(a) Measured force at different levels of displacement. **(b)** The relationship between and measured the arm is feeling.

Experiments #2

	30 degrees	60 degrees	90 degrees
1mm (AVG Pa151.83)	3	3.4	2.8
2mm (AVG Pa 155.83)	3.9	4.2	2.6
3mm (AVG Pa 164.54)	3.9	4.2	2.6
4 mm (AVG Pa 171.61)	3.8	4	2

The average rating of doppler at a certain level of displacement and angles.

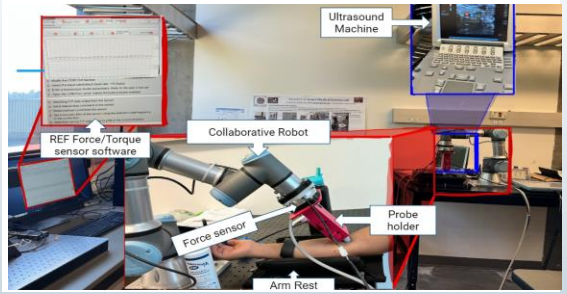
Experiments #3

(a)	Vertical/Horizontal	Control group
Left vein	0.21cm/0.36cm	0.58
Right vein	0.19cm/0.25cm	0.76
Artery	0.36/0.34	1.06

(b)		30 degrees	60 degrees	90 degrees
1mm (AVG Pa151.83)	Artery:	1.09	1.07	0.97
	(R)Vein:	1.04	0.89	1.06
	(L)Vein:	0.98	0.93	0.73
2mm (AVG Pa 155.83)	Artery:	1.20	1.04	0.98
	(R)Vein:	1.01	0.93	1.03
	(L)Vein:	0.90	0.64	0.80
3mm (AVG Pa 164.54)	Artery:	1.16	0.95	0.96
	(R)Vein:	1.22	0.77	0.91
	(L)Vein:	0.97	0.79	0.79
4 mm (AVG Pa 171.61)	Artery:	0.86	0.87	0.99
	(R)Vein:	0.00	1.08	1.11
	(L)Vein:	0.00	0.78	0.72

Overview of the brachial vein and arteries vertical and horizontal diameter.
(a) the control group. **(b)** Has highlighted values that are within our control group.

Experiment setup



Conclusion

Based on these experiments, the best ultrasound image was taken when the probe was at an angle of 60° and with 2 mm of indentation and a pressure of 155.83 Pa.
- The measurements also lined up with online references.

Skills

- Designing and prototyping armrest and probe holder using SolidWorks/3d printing
- Data acquisition and analysis using force sensor
- Ultrasound basics and vessel mapping
- Collaborative robot programming

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