Physics Optimization Project

Kayla, Shweta, Ashley

Pancreas


SAMSUNG
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KN
PHYSICS LAB, ASHLEY KAYLA SHWETA
05062025-034803PM
TIs 0.4 MI 0.97
05-06-2025
04:09:24 PM
Abdo-Phys
CA1-7AD
13.0cm
52Hz
[2D]
Pen1
Gn 45
DR 80
FA 0
P 90%
0
5
10
TRV PANC


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PHYSICS LAB, ASHLEY KAYLA SHWETA
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Abdo-Phys
CA1-7AD
12.0cm
28Hz
[2D]
Gen
Gn 37
DR 136
FA 4
P 90%
0
5
10

Bladder


SAMSUNG
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PHYSICS LAB, ASHLEY KAYLA SHWETA
05062025-034803PM
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05-06-2025
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Abdo-Phys
CA1-7AD
11.0cm
60Hz
[2D]
Pen1
Gn 37
DR 80
FA 0
P 90%
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0
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10
TRV BLADDER


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05-06-2025
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CA1-7AD
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50Hz
[2D]
Gen
Gn 45
DR 136
FA 6
P 90%
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HAR
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TRV BLADDER

Thyroid


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SHWETA SCAN MADISON
12062025-030225PM
TIs 0.3 MI 1.1
12-06-2025
03:06:01 PM
THY PHYSIC
LA3-14AD
2.5cm
56Hz
[2D]
Pen
Gn 46
DR 80
FA 7
P 90%
0
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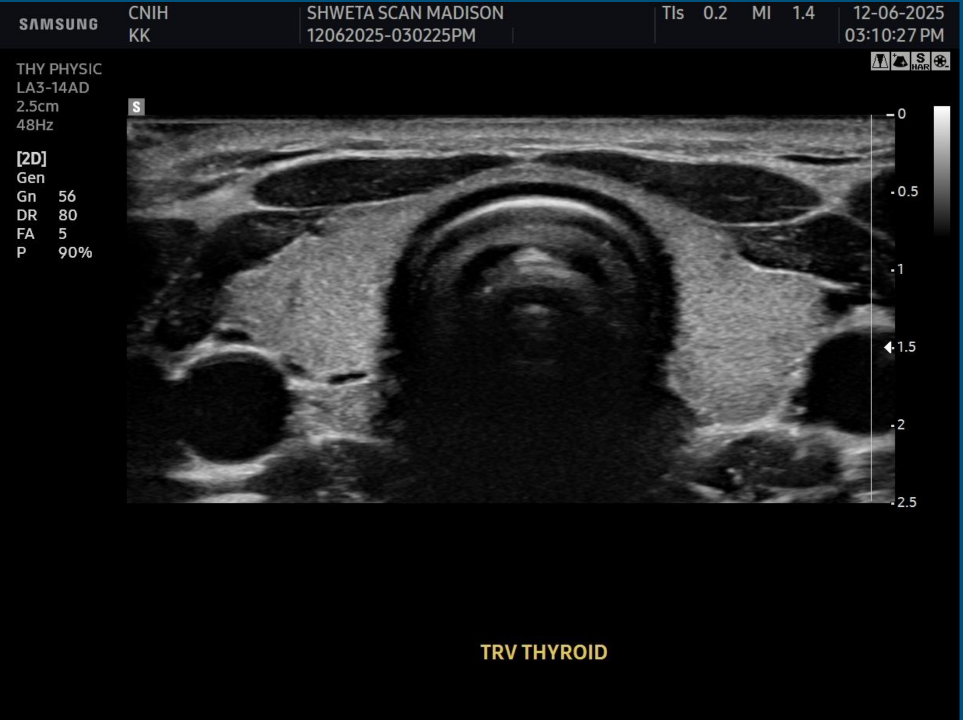
TRV ISTHMUS


SAMSUNG
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SHWETA SCAN MADISON
12062025-030225PM
TIs 0.2 MI 1.4
12-06-2025
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THY PHYSIC
LA3-14AD
2.5cm
48Hz
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Gn 56
DR 80
FA 5
P 90%
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1.5
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2.5
TRV THYROID

Lab Project 2: Optimization

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Canadian National Institute of Health

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Optimization of image quality is an essential component for an accurate sonographic exam, and potential diagnosis. In this lab project, we applied various adjustments to the machine to improve sonographic images of the pancreas, bladder, and thyroid. Among the three organs, we made various adjustments that addressed their individual characteristics in relation to factors such as tissue composition, location, and depth. Each adjustment was made individually in order to properly evaluate its specific impact on image quality.

TRV PANC (Ashley)

While scanning the pancreas, the initial image showed significant noise, poor contrast, and blurry tissue borders. This made it difficult to visualize the pancreas. We turned on S-Harmonics (spatial compound harmonics) which is a setting that makes images clearer by picking up higher-frequency echoes that are naturally created as the sound moves through the body's tissues. It allows the transducer to transmit a lower frequency and in return, we receive a higher harmonic frequency back. This results in better contrast and clearer borders while minimizing side lobes and reverberation. As a result, the borders of the pancreas were sharper, and internal structures became easier to assess.

Clear Vision is a feature that helps improve image clarity by reducing noise and artifacts, allowing the tissue borders and internal structures to appear more clearly. When we activated Clear Vision, the system applied advanced post-processing algorithms that reduced speckle noise while preserving true anatomical detail. This smoothing of the speckle pattern enhanced tissue boundaries and improved overall sharpness. As a result, structures like the pancreatic duct and parenchymal texture became much easier to visualize, contributing to a clear, diagnostic-quality image.

Increasing the power on the machine boosts both penetration and image brightness. Since the pancreas sits deeper and can be partially blocked by bowel gas, raising the output power strengthens the transmitted sound waves. This resulted in stronger returning echoes from the deeper tissues, brightening the image and improving the signal-to-noise ratio. As a result, the pancreatic tissue that was previously difficult to see became much clearer.

TRV BLADDER (Shweta)

Changing frequency to “Gen”(General): Before the change, initially, the urinary bladder image was acquired using a lower frequency setting, which resulted in deeper penetration but lower spatial resolution. The bladder borders appear less crisp, and subtle internal echoes could not be clearly differentiated from artifacts. After the change: After adjusting the frequency to “Gen”, a mid-range frequency setting, the image displayed a noticeable improvement in detail. The bladder wall became more sharply defined, and the internal lumen showed fewer artifacts and clearer contrast between anechoic and hypoechoic areas. Why this worked: The frequency of the transducer affects the penetration and spatial resolution. Higher frequency provides better axial and lateral resolution but limited penetration. Lower frequency penetrates deeper but reduces resolution. The “Gen” setting is a balanced compromise, ideal for pelvic imaging in the average body habitus. By selecting this frequency, we maximized resolution without sacrificing too much depth, making it optimal for imaging the bladder.

Adjusting the Dynamic range (DR) from 80 to 136. Before the change: Prior to modifying the dynamic range, the image displayed higher contrast with fewer shades of gray. It also caused a loss of subtle tissue detail, making the image look slightly harsh and reducing soft tissue differentiation. After the change: Increasing the DR to 136, I introduced more shades of gray into the image, leading to a smoother and more detailed appearance. The tissue transition becomes more gradual, which helps visualize the structure adjacent to the bladder more clearly. Why this worked: In higher DR, more gray tones, smoother image, which is better for soft tissue differentiation. Lower Dr is for higher contrast, fewer shades, and good for borders, but not for subtle differences.

Before the change, the image initially showed reverberation artifacts and clutter within the bladder, with a high frame average that made scanning sluggish and reduced temporal resolution. The anterior wall had difficulty differentiating between actual tissue and reverberation artifact, making it challenging to evaluate the bladder's internal features accurately.

After the change, activating tissue harmonic imaging significantly reduced clutter and reverberation artifacts, especially in the near field, resulting in a much clearer visualization of the bladder's internal lumen. Additionally, reducing the frame average allowed for quicker image updates, improving temporal resolution and making it easier to assess motion, such as bladder filling. This worked well because harmonic imaging works by receiving reflected echoes at twice the transmitted frequency. These harmonic signals have narrower beam widths and fewer side lobes, which improves lateral resolution and reduces near-field artifacts, such as reverberation. Frame averaging blends multiple frames into one to reduce noise and smooth the image, but a higher setting slows down the image refresh rate. By lowering the frame average, the image becomes more responsive and real-time, which is crucial for observing bladder filling, motion artifacts, and distinguishing between true tissue and artifact.

TRV THYROID (Kayla)

Prior to the optimizations made for our image of the thyroid, the line density was set to medium. Line density refers to the number of scan lines used to create the image. When we increased the line density from medium to high, it improved the spatial resolution. This allows for finer details, and a sharper overall image. An increase in lateral resolution leads to a decreased frame rate, but in this particular instance, improved lateral resolution is more beneficial. With the glands margins being more clearly defined, a smoother image is created.

Having no harmonics can sometimes improve penetration in deeper tissues, however, this benefit is limited for superficial structures like the thyroid. When there were no harmonics, our image appeared grainy and contained more noise, making it difficult to visualize any nodules or vascularity if there were any. S-harmonics improved our image quality by using naturally occurring harmonic frequencies generated within the tissue. These harmonic frequencies have narrower beam widths and reduced side lobes, which improve contrast resolution and provide clearer, sharper images of the thyroid's fine structures.

Initially, the thyroid borders appeared blurry, which made it difficult to distinguish the gland from surrounding tissues. We raised the edge enhancement from 1 to 3 which sharpened the borders of the thyroid, adjacent structures, and surrounding tissue. Edge enhancement works by amplifying the contrast between areas of varying and similar echogenicities, helping define the margins more precisely and highlight subtle differences in tissue texture. This adjustment contributed to improved structural resolution and overall image clarity.

We applied specific optimization techniques to improve image quality for the pancreas, bladder, and thyroid. For the pancreas, enabling S Harmonics reduced artifacts and enhanced image clarity. In the bladder, setting the frequency to Gen, increasing the dynamic range from 80 to 136, activating harmonics, and raising the frame rate from 0 to 6 improved contrast, sharpness, and motion depiction. For the thyroid, adjusting the frequency to Gen, increasing line density, enabling S Harmonics, and setting edge enhancement to 3 produced sharper borders and improved spatial resolution. These adjustments demonstrate the importance of physics-based parameters in achieving high-quality diagnostic imaging.

References

Kremkau, F. W. (2021). Sonography: Principles and instruments (10th ed.). Elsevier.

Canadian National Institute of Health. (2025). Physics II lecture slide presentations [Lectures 2-6]. Unpublished course materials.