

Toward an Objective Metric of Uniformity in Ultrasound

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Disclosure

Funding for this project was provided by **Atirix Medical Systems** through their internship program

- Atirix sells the QC-Track[®] system for imaging QC

The **University of Minnesota** does not endorse nor is in any way affiliated with Atirix Medical Systems, Inc. or the work presented in this talk

Data used for analysis in this project was provided by **UT Southwestern + Parkland Health**

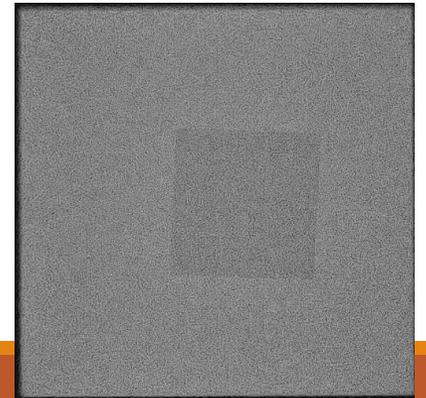
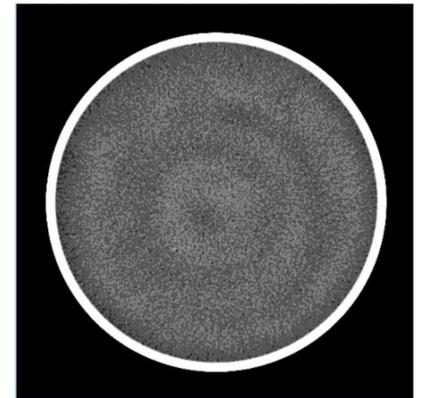
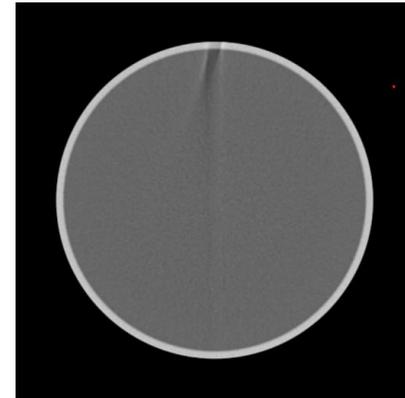
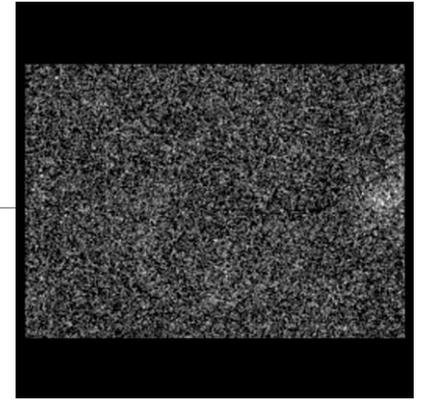
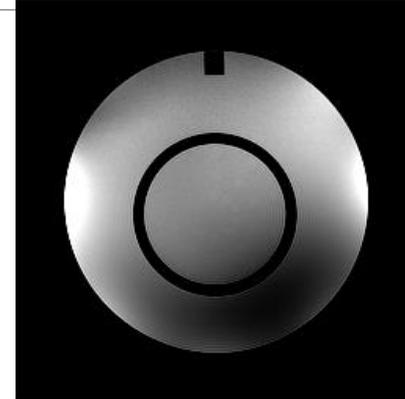
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Systems

About General Uniformity

- ❖ Non-uniform brightness or intensity
- ❖ Dead or defective detector elements
- ❖ Noise and interference
- ❖ Artifacts
- ❖ Miscalibrated gain or sensitivity



About Ultrasound Uniformity

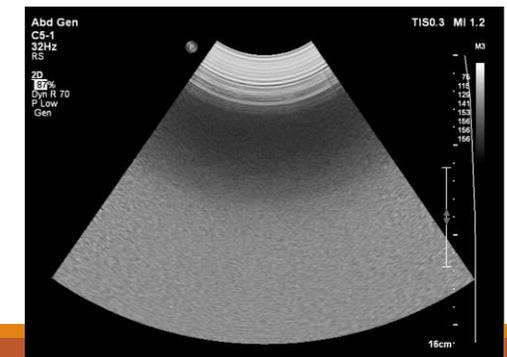
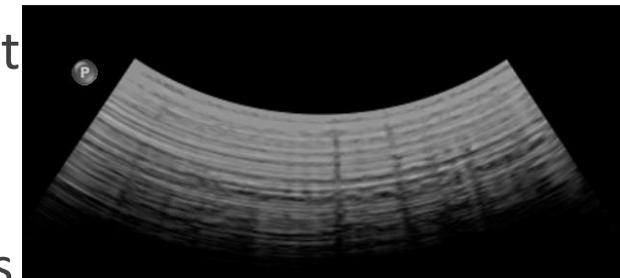
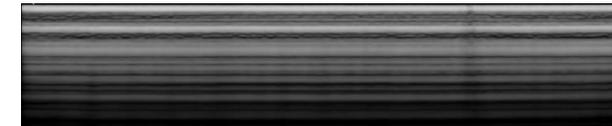
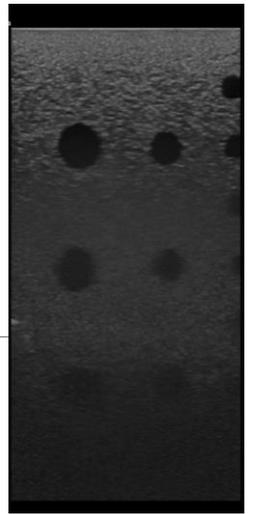
Ultrasound uses reflected sound waves - Brightness depends on tissue acoustic impedance differences, not radiation absorption

Depth dramatically affects signal strength - Rapid sound attenuation requires aggressive depth-dependent gain compensation (TGC)

Transducer is both transmitter and receiver - Element failures impact both pulse generation and echo detection

Beam geometry varies with depth - Focus and beam width change throughout the image, creating depth-dependent uniformity patterns

Real-time imaging demands continuous uniformity - Must maintain quality at 15-60 frames per second, not just single images



What is a Good Metric?

- ❖ Quantitative and objective
- ❖ Encompasses speckle and brightness variation
- ❖ Practical to measure routinely
- ❖ Correlates with image quality perception
- ❖ Sensitive to clinically relevant defects

Background Literature:

Scorza et al. (2016)

https://doi.org/10.1007/978-3-319-32703-7_93

Zhao and Pietikainen. (2007)

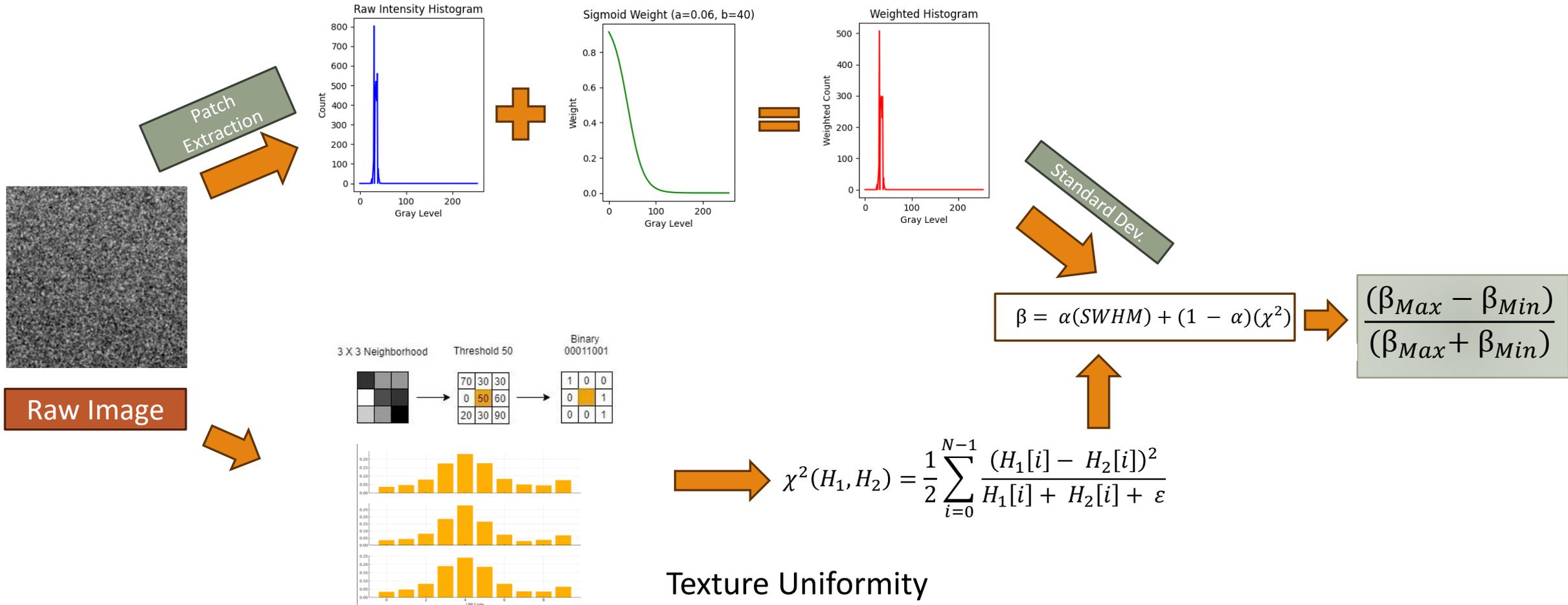
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Huang et al. (2011)

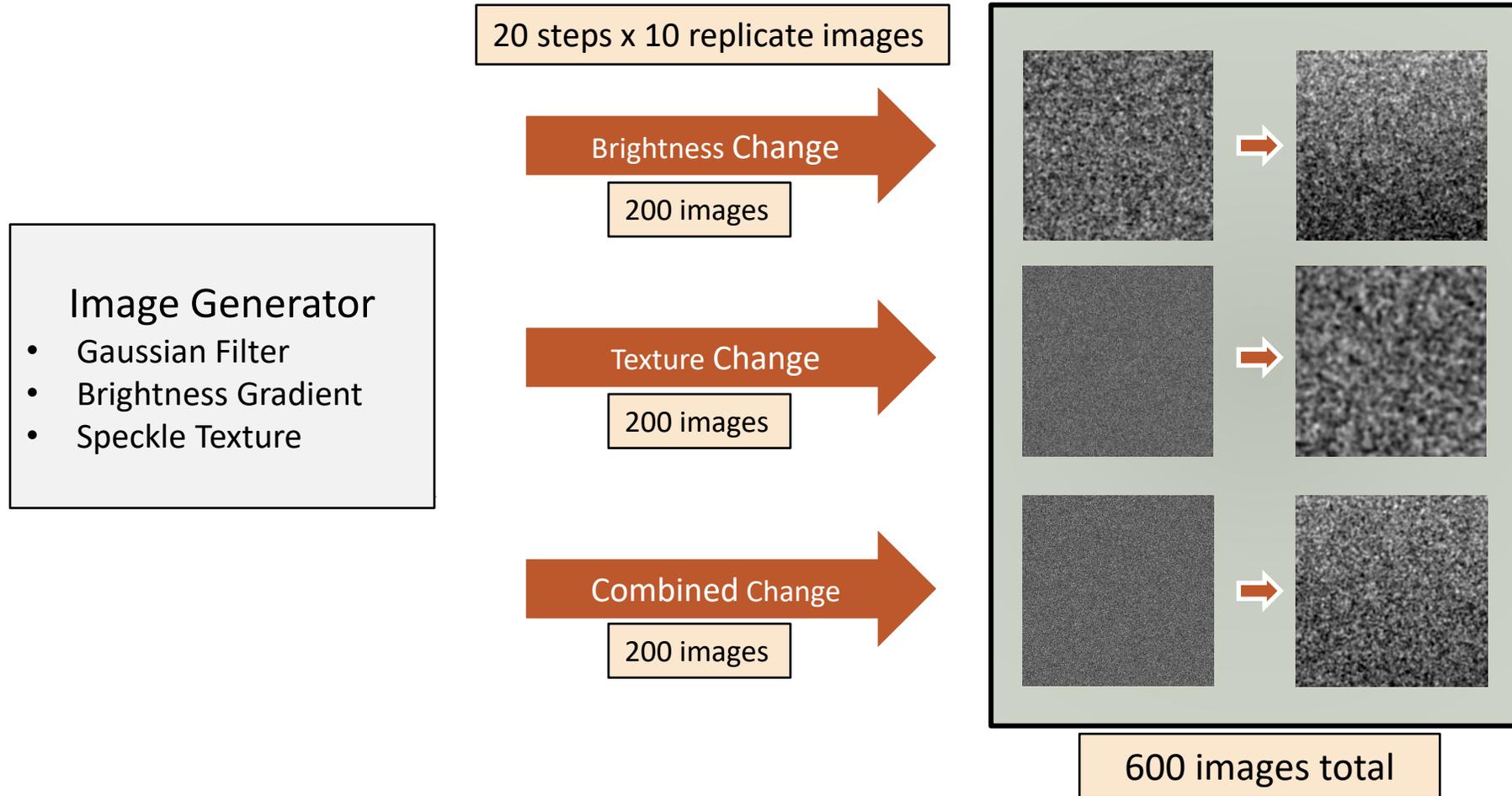
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Uniformity Analysis Method

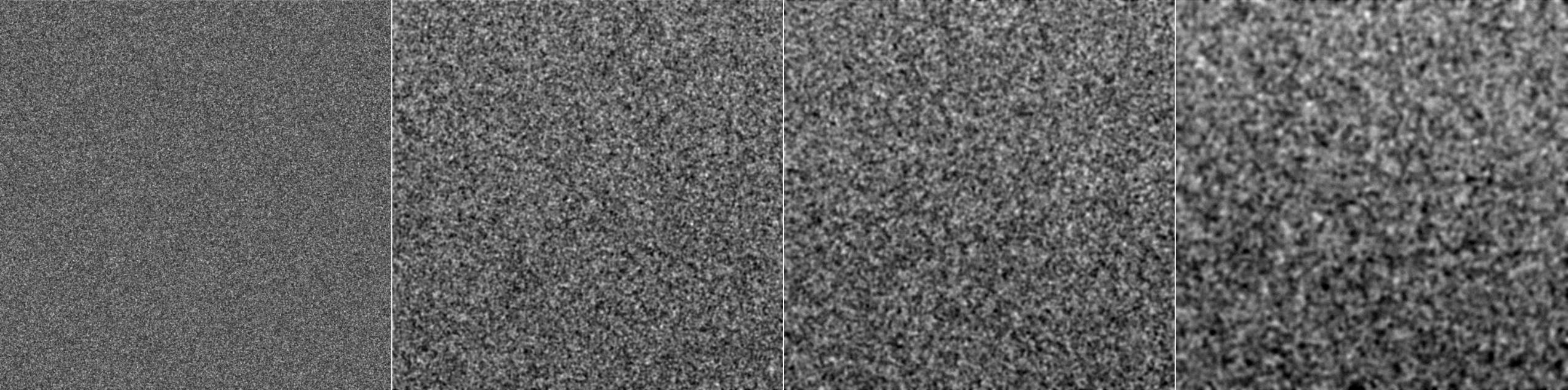
Brightness Uniformity



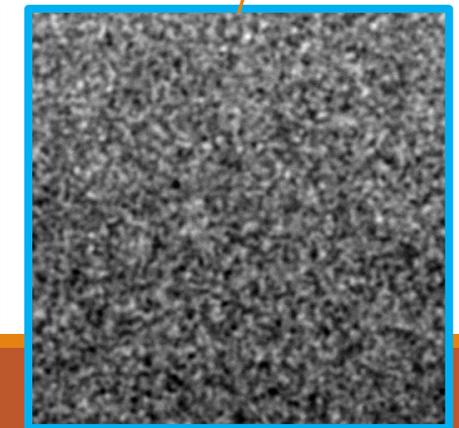
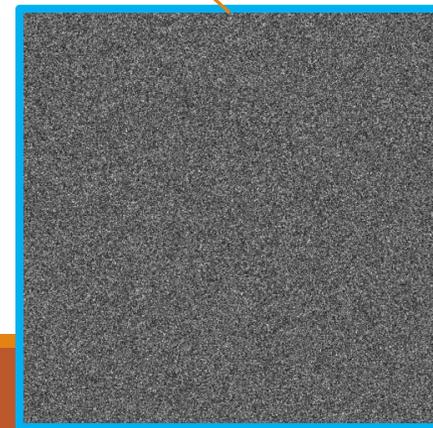
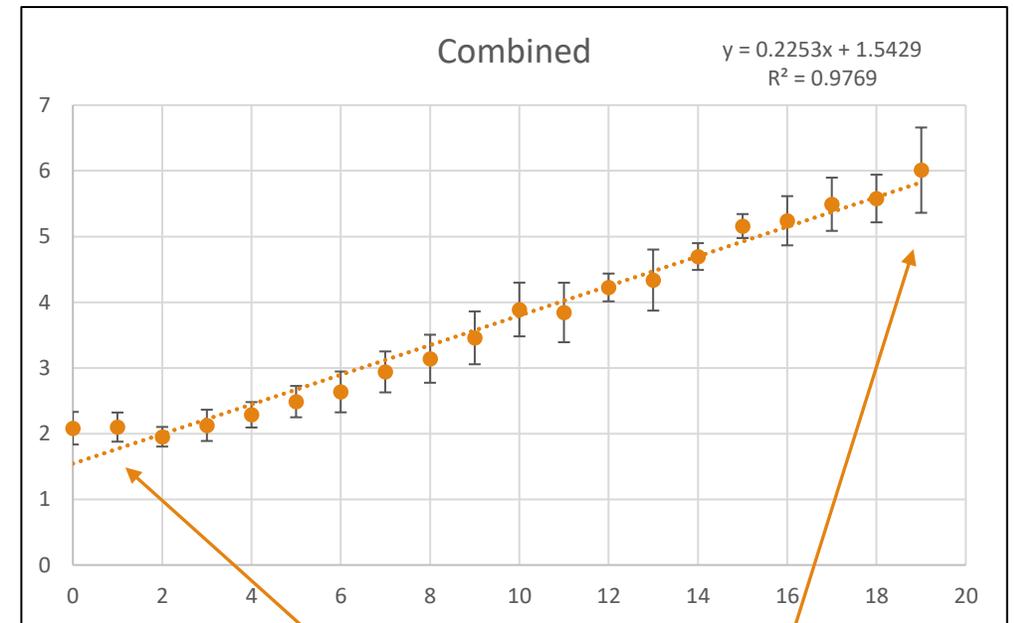
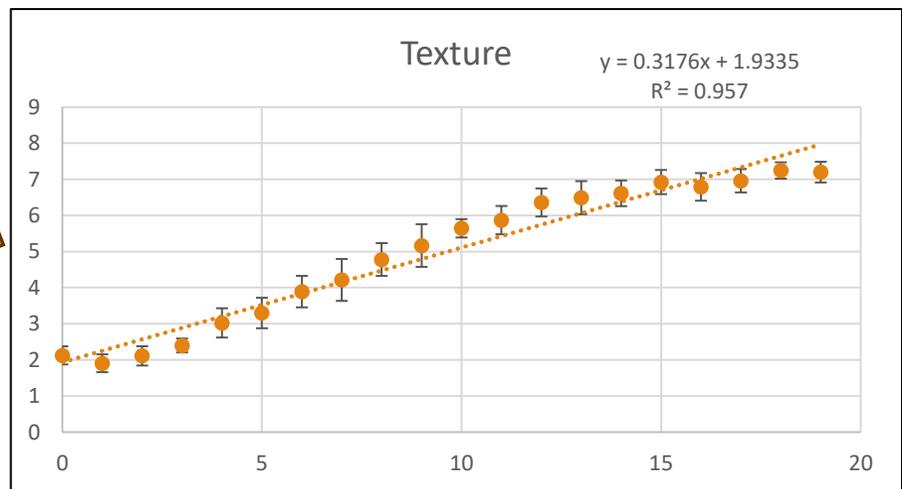
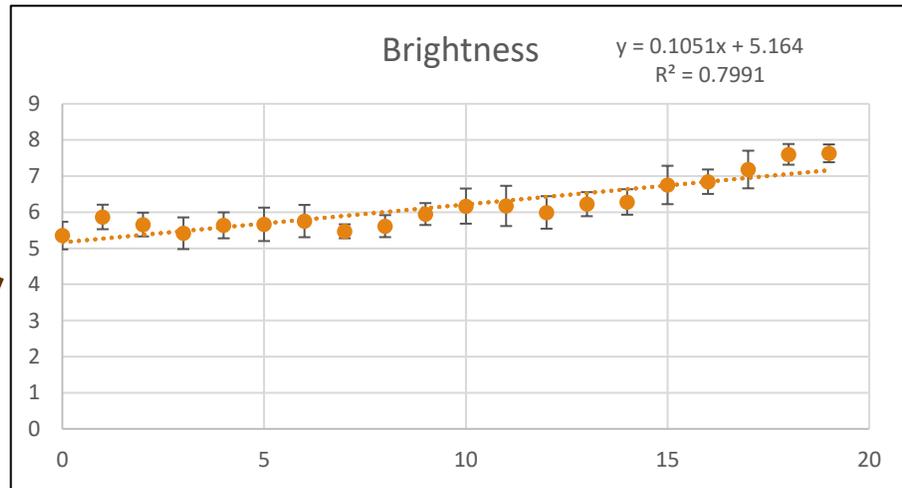
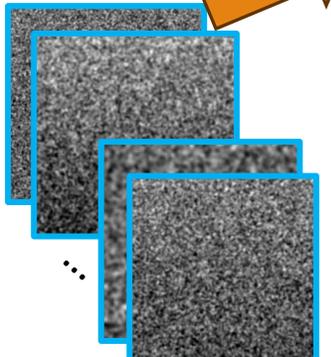
Systematic Testing



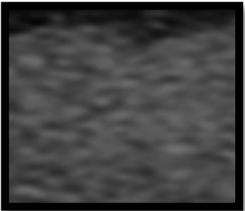
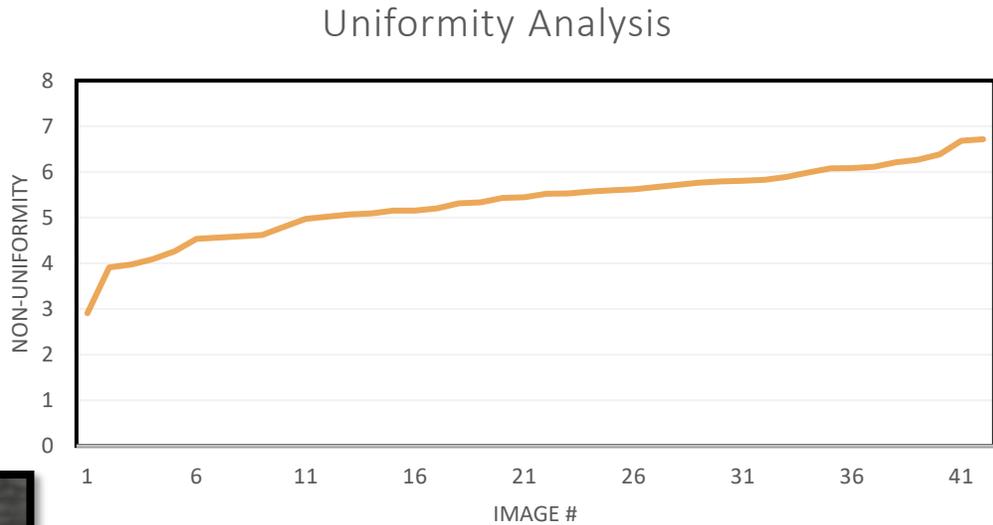
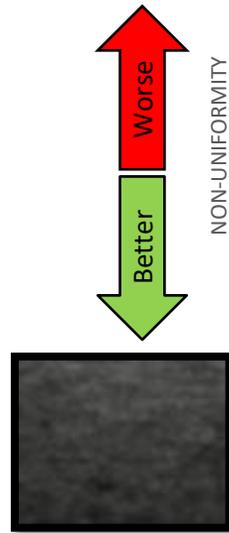
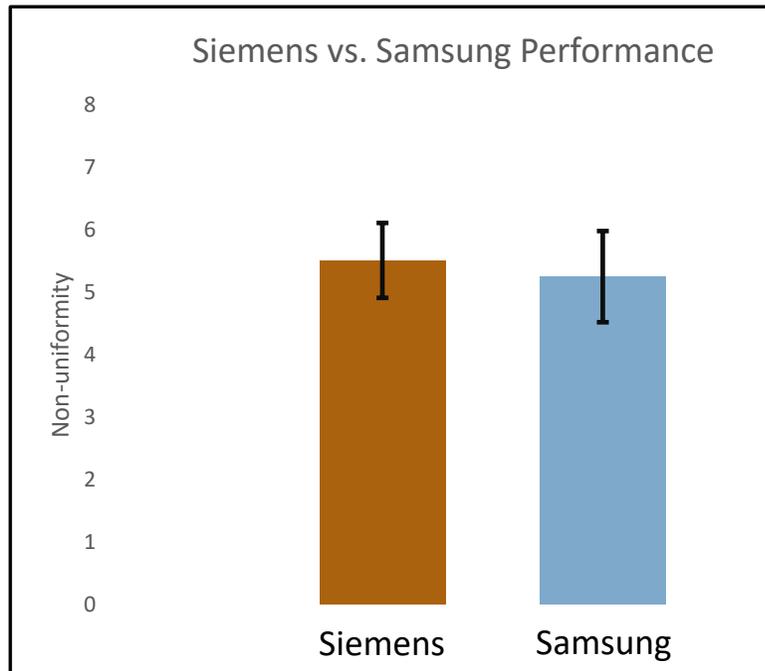
Systematic Image Degradation



Systematic Results



Clinical Results



Conclusion

- ✓ **Quantitative and objective**
- ✓ **Dependent of speckle and brightness variation**
- ✓ **Practical to measure routinely**

Future Directions

Correlate metric to perceived image quality

Breadth of clinically relevant acquisition modes

- geometry, continuous, greater variety of transducers, etc.

Thank you!

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