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UC San Diego
Department of Radiology

HEALTH
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FULLY AUTOMATED DYNAMIC FRAME RATE ADJUSTMENTS IN DIGITAL SUBTRACTION ANGIOGRAPHY

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DISCLOSURES

The authors (BTC, FN, GCF), along with the University of Utah, have filed a provisional patent application on this work.

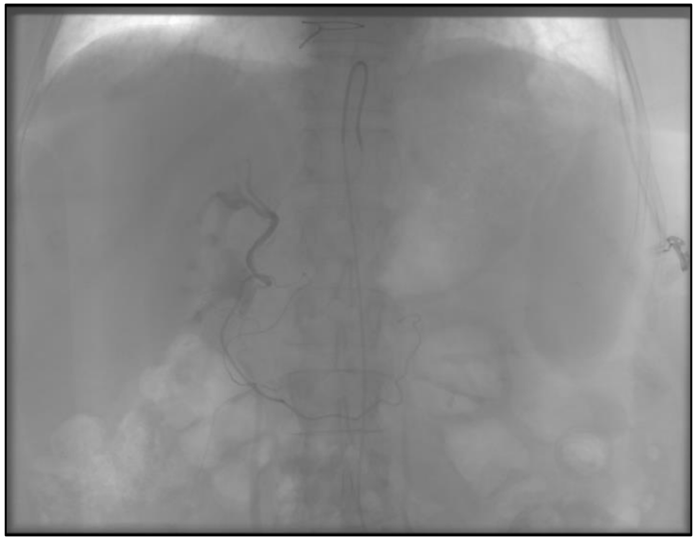
OVERVIEW

- The Problem
- Our Solution
- Results
- Clinical Significance
- Future Work

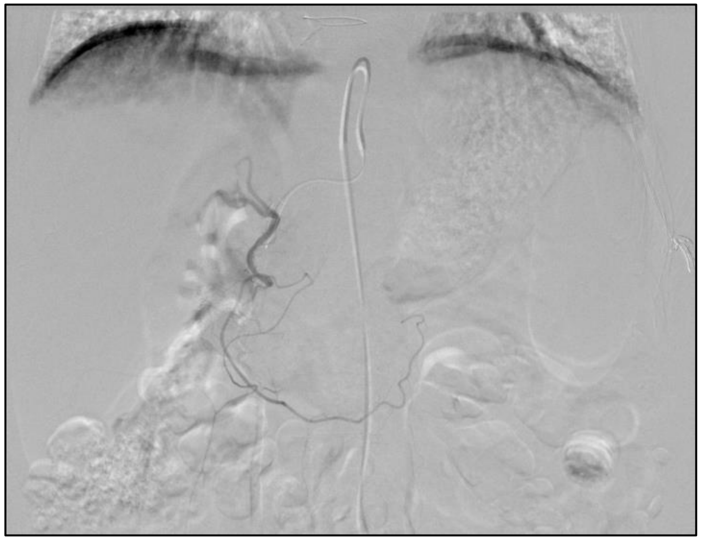
DIGITAL SUBTRACTION ANGIOGRAPHY

Mask Frame (Pre-contrast)

Native Frame (post-contrast)

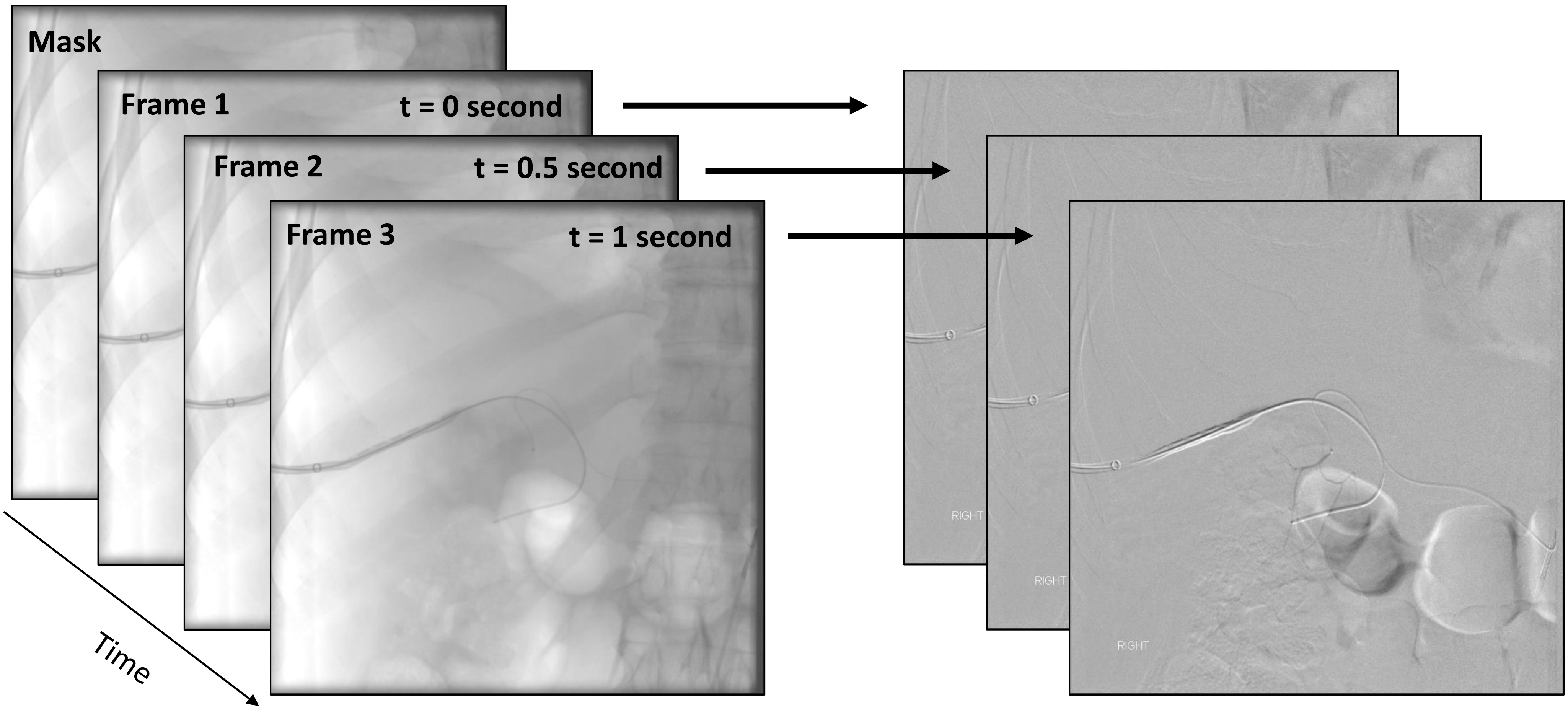


Digital Subtraction



- Digital Subtraction Angiography (DSA) is a commonly used method to visualize vasculature throughout the body
- DSA images are created by subtracting a pre-contrast x-ray image (or mask) from subsequent images after the contrast agent has been introduced

DIGITAL SUBTRACTION ANGIOGRAPHY



Native X-Ray Images

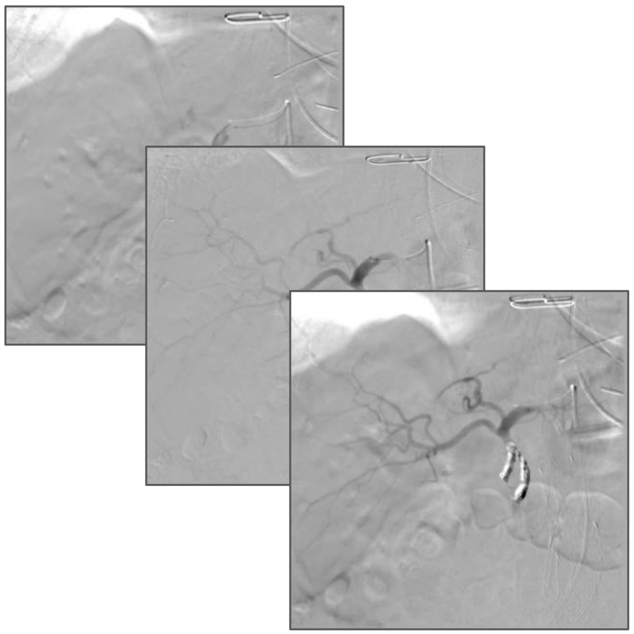
Digital Subtractions

Frame Rate = Number of Frames / Time (seconds)

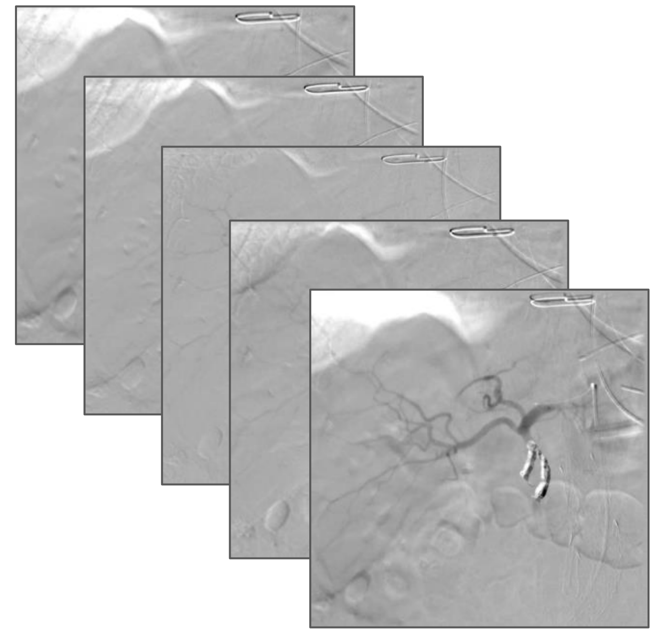
THE PROBLEM

Patient motion creates misalignment between subtracted images, generating motion artifacts

SIGNIFICANT MOTION NECESSITATES HIGHER FRAME RATES



3 fps



6 fps

lower radiation,
lower image quality

→

higher radiation,
higher image quality

CURRENT APPROACH: BEST GUESS PREOP

Frame rate is selected preoperatively based on the amount of expected motion

Cerebral angiography: **1-3 fps**
Visceral angiography: **4-12 fps**
Pulmonary angiography: **15-30 fps**

Motion is difficult to predict, and **preoperative frame rates selections are often inaccurate**

OUR SOLUTION: DYNAMIC FRAME RATE ADJUSTMENTS

Key Innovation

Step 1 — Start with standard frame rate based on procedure

Step 2 — Assess degree of motion in first series

Step 3 — Optimize frame rate based on the degree of motion

Step 4 — Perform next DSA series with optimized frame rate

1. Minimize unnecessary radiation exposure
2. Maximize diagnostic image quality

MOTION DETECTION AND QUANTIFICATION APPROACHES

Current Approach

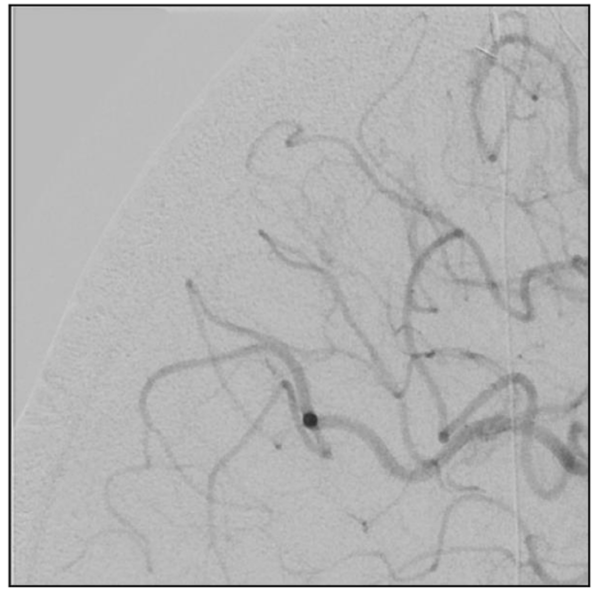
- **Analytical**: Standard deviation of pixel intensities

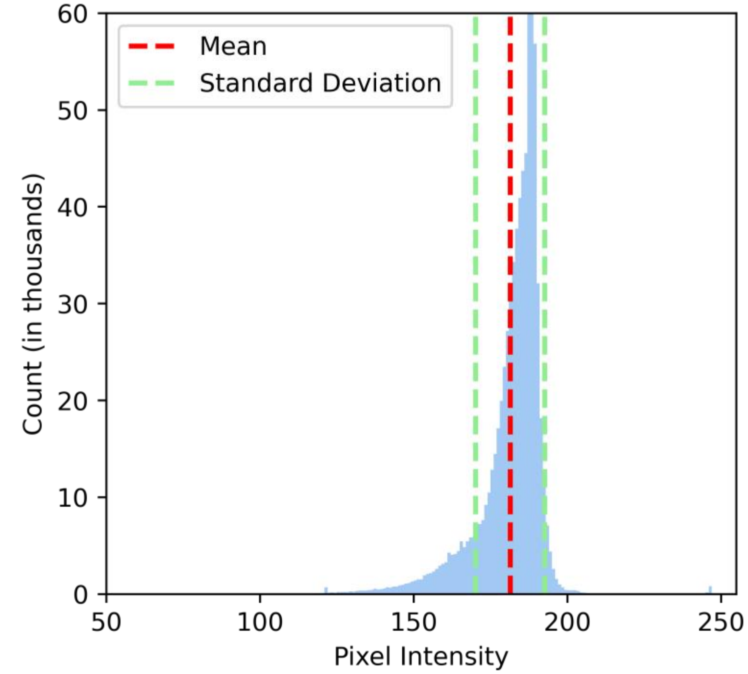
Comparison Approaches (Under development)

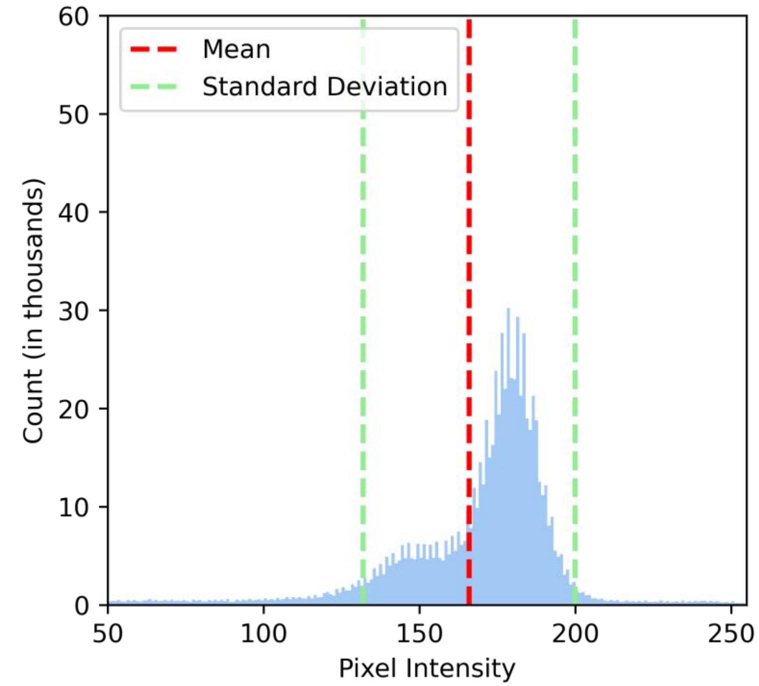
- **Machine learning**: Statistical classifier vs deep learning
- **Classical computer vision**: Feature matching

OUR SOLUTION: STANDARD DEVIATION OF PIXEL INTENSITIES

Cases with a high degree of motion have a higher standard deviation of pixel intensities

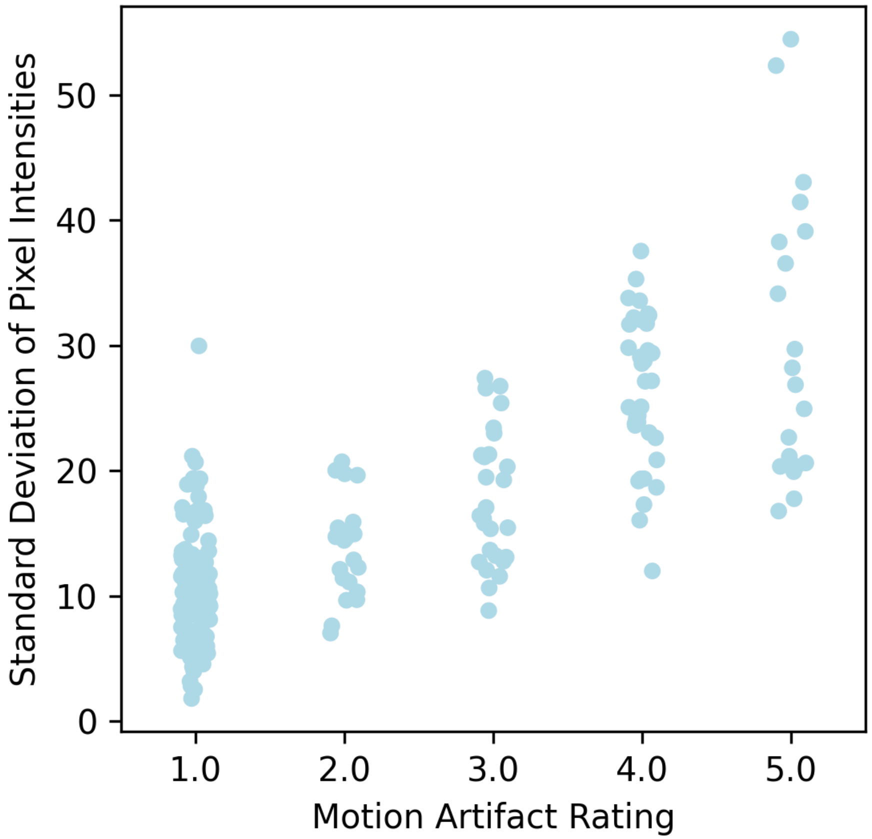


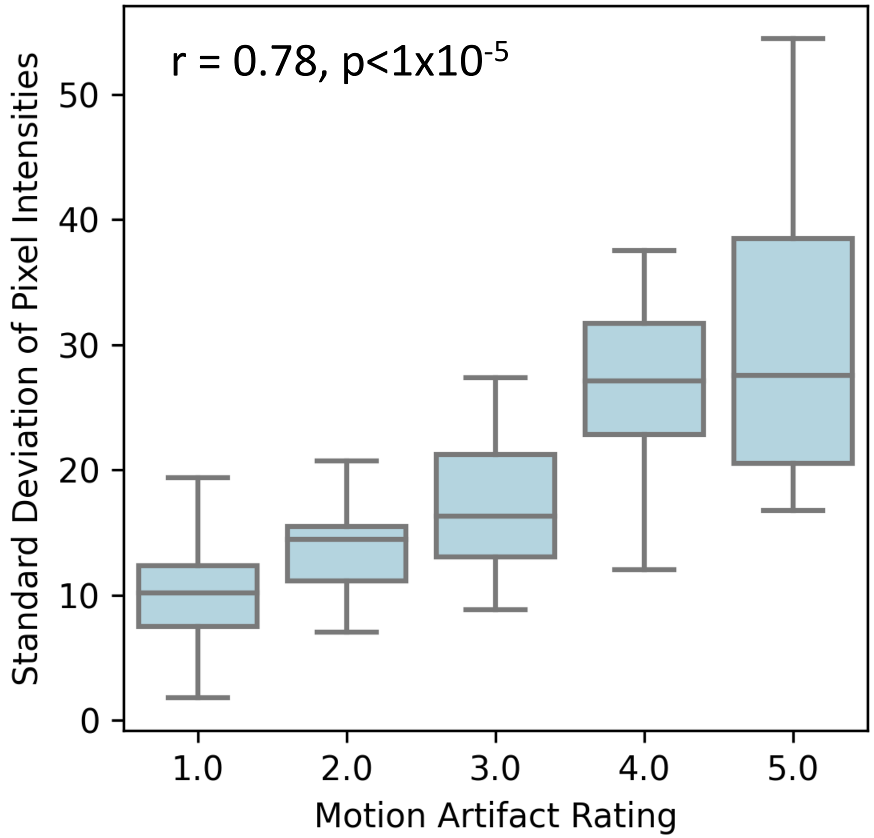




OUR SOLUTION: RESULTS

Proof of concept with 88 patients and 217 DSA series:





This relationship **quantifies the degree of motion artifacts**, and we can use that information to dynamically optimize the frame rates

ALTERNATIVE APPROACHES

Machine Learning: categorical motion classification

Data: 88 patients, 217 DSA series (80/20 train/test split)

Ground Truth: Manual motion classification, scale 1 (minimal motion) to 5 (maximal motion).

Algorithm: XGBClassifier, v1.6.1

Results: $r = 0.92$, $p<1\times10^{-5}$ on test set

Processing time: 0.011 seconds (per image)

CLINICAL SIGNIFICANCE

- **Universal applicability:** Our approach is independent of procedure or anatomical location.
- **Radiation Safety:** Limiting radiation and has been identified as a key area in the field of radiology by the CDC and RSNA[1,2]
- **Image Quality:** Improving image quality may lead to shorter procedure times, more accurate diagnoses, and more effective treatments

1. https://www.cdc.gov/nceh/radiation/alara.html
2. https://www.aapm.org/org/policies/details.asp?id=2548

NEXT STEPS

Retrospective clinical evaluation:

1. Retrospectively run the automated frame rate adjustment algorithm over a variety of DSA cases
2. Analyze the average frame rate and radiation exposure per procedure
3. Compare the timing and frequency of automated frame rate adjustments with manual adjustment

THE TEAM

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Thank you!

Please contact me with any questions or comments:
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