AI Assistance to Acquire High-Quality FAST Exams

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Introduction

- Trauma is a leading cause of death worldwide, accounting for 10% of all disability-adjusted life years.
- Truncal hemorrhage accounts for half of all preventable deaths in combat
- Focused Assessment with Sonography in Trauma (FAST) is a rapid bedside ultrasound exam to assess internal bleeding, but requires expertise to scan and interpret
- Artificial intelligence (AI) algorithms have the potential to improve the quality and interpretation accuracy of the FAST exam for all users.

FAST Exam for internal bleeding detection

Objectives

- This work aims to develop AI based approaches to improve the view quality and performance of the FAST exam. In particular, we report on
  - Deep learning-based view quality algorithms
  - Deep learning-based zone detection algorithm
- The work is expected to improve efficiency in routine care as well as for mass casualty, combat, and training situations.

Clinical Data Description

- A trained and experienced emergency physician acquired FAST exam images
- 11 Non-trauma volunteers
  - Gender: 5 male and 6 female subjects
  - Age: 22 ~ 64 years
  - BMIs: 21 ~ 34
- Ultrasound system: Philips Lumify handheld ultrasound; S4-1 sector probe
- FAST exam zones
  - Right upper quadrant (RUQ)
  - Left upper quadrant (LUQ)
  - Suprapubic (SP)
  - Two cine loops per zone per subject
- 19,868 image frames

Methods and Materials

Data Annotation setup

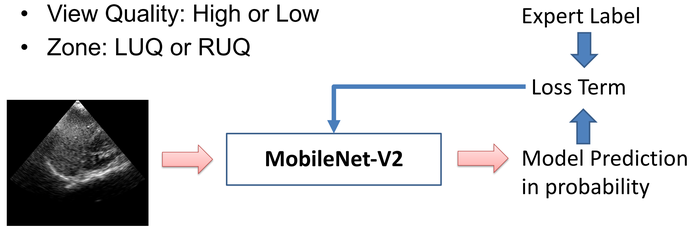
- At least two expert physicians classified images
  - "high" or "low" view quality
- High view quality image defined as good general ultrasound image quality and identifiable anatomical features:
  - RUQ: Liver, Liver tip, kidney, or diaphragm
  - LUQ: spleen, spleen-tip, kidney, or diaphragm

Data for Deep Learning model training and testing

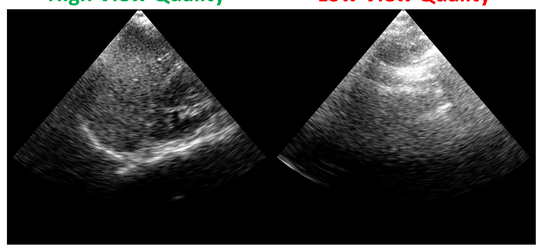
- Input: 2D image frames
- 15,453 high view quality image frames
  - RUQ: 6,856 frames
  - LUQ: 8,588 frames
- 4,415 low view quality image frames

Supervised image classification network

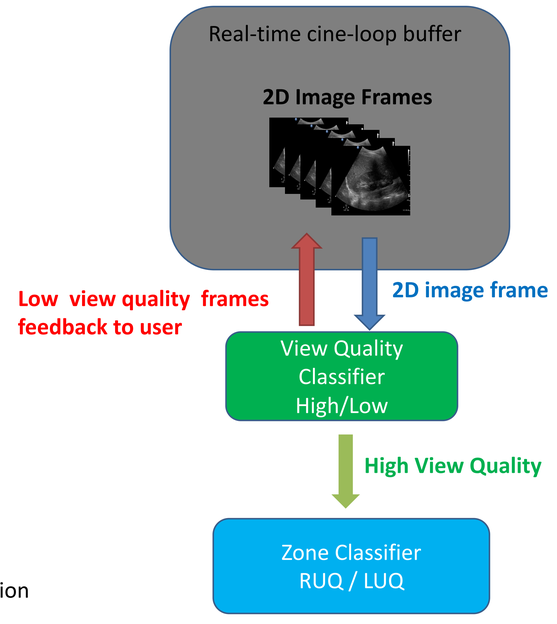
- Deep learning-based model learns image classification
- Variant of MobileNet-V2 chosen due to small processing and memory footprint.
- Image augmentations performed:
  - Gaussian noise insertion
  - Horizontal flips
  - Brightness augmentation
- Problem set up as binary classification:
  - View Quality: High or Low
  - Zone: LUQ or RUQ



Training process of deep learning-based classification model



Example of high and low view quality labeled images

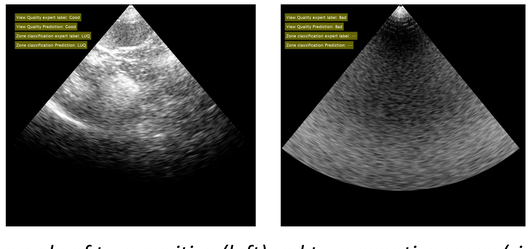


View quality and zone classifier workflow

Results

- Four-fold cross validation was performed to evaluate the performance of developed models.
- The view quality classification algorithm showed an average accuracy of 87 ± 2.6% across 4-folds.
- The zone classification algorithm showed an average accuracy of 84 ± 8.8% across 4-folds.

	Avg. Accuracy	Avg. Std
View Quality	87%	2.6%
Zone Classification	84%	8.8%



Example of true positive (left)and true negative cases (right)

Discussion & Conclusions

- Deep learning-based model showed promise for automated view quality and zone classification
- With carefully selected data augmentation, deep learning-based model can perform well with small training dataset
- Good performance was achieved using a mobile friendly network, enabling applications for field use
- The AI algorithm can alert users that they are acquiring images with relevant anatomy present with high accuracy
- This feature is particularly beneficial for new or less-experienced ultrasound users

Future Directions

- Future work will focus on further development and testing of the algorithms in a trauma setting and explore the effectiveness of AI assistance in moving towards less dependence on operator skill in performing the FAST exams.
  - Improve model performance on difficult cases such as transition frames
  - Merge view quality and zone classification models into single inference model for faster inference
- There is a potential for the output of image quality and zone classification algorithms to provide live feedback for less experienced physicians as a training tool.
- This feature may become particularly useful in mass-casualty and combat scenarios to provide highly accurate and rapid triage when it becomes accessible to trained first responders.

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