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Development of a Quantitative Contrast-to-Noise Measurement Software for Fluoroscopic Imaging

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ABSTRACT

Purpose:
Routine fluoroscopy quality assurance evaluations rely heavily on qualitative assessments of image quality, which can be affected by reader variability and may limit consistent monitoring of system performance. This study describes the development of an open-source Python-based software tool to provide objective and reproducible measurements of signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) for fluoroscopic image quality assessment.

Methods:
The graphical user interface was developed entirely in Python using open-source libraries. Users load a DICOM fluoroscopy loop or last image hold and select the approximate center of a contrast object. The software automatically identifies the contrast object's center and generates corresponding regions of interest (ROIs) to calculate SNR and CNR. The tool was developed using the Leeds TO10 phantom and adapted for use with the Sun Nuclear Contrast/Detail Phantom (Model 1151). Performance was evaluated on fluoroscopy images acquired during annual evaluations of multiple clinical systems.

Results:
The software has been used internally for 9 months across 40 images from eight fluoroscopy system models representing Philips, Canon, and Siemens systems, including fixed radiography/fluoroscopy units, image intensifier-based systems, flat-panel systems, and mobile C-arms. The tool successfully generated automated ROIs and provided reproducible SNR and CNR measurements across a range of systems. Limitations identified during implementation included variability in DICOM export capabilities and reduced performance when contrast objects were positioned near the edge of the field of view.

Conclusion:
This Python-based tool provides an accessible method for quantitative fluoroscopic image quality assessment. Automated ROI generation reduces operator dependence and provides a standardized approach for SNR and CNR measurement during fluoroscopy quality assurance evaluations.

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INTRODUCTION

Quantitative assessment of fluoroscopic image quality is challenging in routine quality assurance evaluations, where visual assessments remain the primary method of evaluation. These qualitative assessments are subject to reader variability and may result in inconsistent image quality evaluations over time. This study presents an open-source Python-based software tool designed to provide objective and reproducible measurements of signal-to-noise ratio (SNR) and contrast-to-noise ratio (CNR) for fluoroscopy system benchmarking.

METHODS AND MATERIALS

The software was developed in Python and utilizes open-source libraries including Tkinter, Matplotlib, NumPy, Pydicom, SciPy, OpenCV, and PIL. The program is launched through a terminal, and users enter the DICOM file path into the text box to load an image (Figure 1, top). If a stored fluoroscopy loop is loaded, a central frame will be displayed. After displaying the image (Figure. 1, bottom), the user clicks near the center of a contrast object. The software automatically identifies the object's center and generates three concentric square regions of interest (ROIs): one ROI contained entirely within the contrast object and two surrounding ROIs used to define an equivalent-area background region. The calculated SNR and CNR are displayed on the image, while the mean pixel value and standard deviation of the ROIs can be exported. Additional contrast regions can be analyzed as needed.

RESULTS

This software has been used internally for 9 months across multiple fluoroscopy systems, including fixed radiography/fluoroscopy units, image intensifier-based systems, flat-panel systems, and mobile C-arms. Forty fluoroscopy images acquired during annual evaluations of forty-two system models from Philips, Canon, and Siemens were successfully analyzed to establish SNR and CNR baselines. The software successfully generated automated ROIs, enabled analysis of multiple contrast regions within an image, and provided quantitative SNR and CNR measurements with minimal user input.
Implementation across different systems identified practical limitations, including variability in DICOM export capabilities between units. Some systems were unable to export fluoroscopy loops through PACS, limiting analysis to last image hold images. Additionally, contrast objects positioned near the edge of the field of view could result in incomplete ROI placement; repositioning the phantom toward the center of the field resolved this issue.

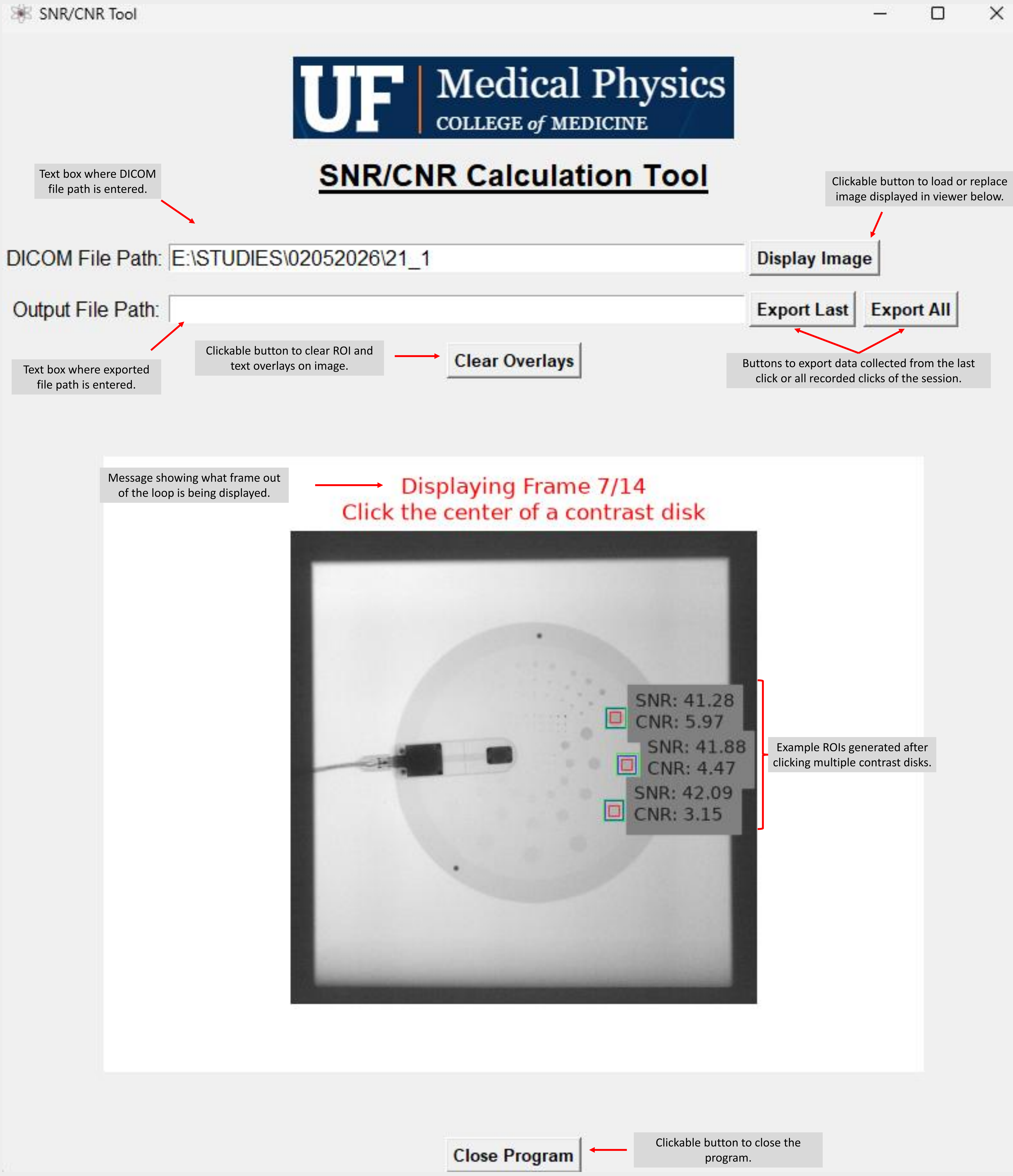

Figure 1. Screen capture of the CNR Tool with a central frame of fluoroscopic loop displayed. Four different contrast disks were clicked and the automatic ROIs and corresponding calculations are shown.

DISCUSSION

This software is available upon request and includes the Python source code and required dependencies. The current version represents an early stage of development, with ongoing refinement to improve robustness and usability.
Current limitations include reduced performance when contrast objects are positioned near the edge of the image or when background noise texture is highly variable. Additionally, analysis of fluoroscopy loops with a large number of frames may be limited. Despite this, the software has demonstrated consistent performance across full-field fluoroscopy images acquired using the largest available field of view on multiple fluoroscopy systems. Future development will focus on improving image processing robustness and implementing additional functionality such as zoom.

CONCLUSIONS

This software provides an accessible method for quantitative SNR and CNR measurements in fluoroscopy images. Automated ROI generation reduces operator dependence and improves reproducibility of low-contrast detectability assessments. This tool provides an objective alternative to qualitative image quality assessments and enables more consistent monitoring of fluoroscopic system performance.