

Umbilical Artery Classification Using Machine Learning/Artificial Intelligence.

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Background/Synopsis

Machine learning and artificial intelligence has been successfully applied to range of different medical problems. Computer models for image classification could be useful for obstetricians to aid in identification and detection of ultrasound anomalies. Potential ML/AI classification problem is single umbilical artery anatomy occurring in 1% of single pregnancies but correlating to 13-56% fetal anomalies. Ability for an image classification based upon vessel structure could be a useful tool in clinical practice. Therefore, a computer-based image-classification model would be beneficial in identification of patients requiring additional resources.

Objective/Purpose

Goal of this work is to develop an ultrasound image workflow from blinding to classification of single umbilical arteries. Initial stages concentrated on automating image blinding and clean up preparation for AI training. After image pre-processing, a proof-of-concept study using a small N-size was performed. After demonstrating the ability to identify >85% correctly, a larger N-size study using a couple hundred images was used to compare different AI-image classification networks.

Methods

Research followed an IRB approval and utilized a standard workflow. Initial images were blinded using a physician “block” approach, utilizing different sized rectangles to remove text. Automated methods to blind ultrasound images from PHI and annotating text was developed using either threshold, color filtering or AI-OCR with background in-painting. Small data set (N = 46) composed of transverse and lateral-colored images was used to train and validate a standard convolution neural network. Proof-of-concept research was followed by larger data set using lateral flow colorized ultrasound collection (N>150/group).

Results

Goal was to test and compare different method image pre-processing prior to analysis. Physician blinding had highest demand on high-value resources and variability. Second option applied a “filter” based upon on gray scale threshold or RGB color index. Methods combined with cropping were fastest but were unable to remove all text. Additional “filtering” methods could remove important information due to non-specific approach. Finally, application of an AI-optical character recognition followed by

background in-painting was best at removing PHI and annotating text but required greater computer processing time than crop/filter method. AI-OCR was chosen and automated to “clean” the ultrasound images.

Proof of concept study combined transverse with lateral colorized flow images and showed a successful classification of 100% to 87.5% of test images. Highest accuracy was obtained when a crop and resizing pre-processing method was combined with a pre-trained resnet. Method showed promise despite limitations due to small N-size and limited numbers of traditional gray scale transverse images. Study was expanded to analyze a larger N-size lateral-CFI image repository.

Testing different types of pre-trained AI-image networks, around 300 images in two categories were pre-processed as above. Images were used to train and evaluate 6 different neural networks of three different architectures. When trained with 10 epochs, all of architectures except for one that had an error rate < 10%. Lowest error rate obtained was 1.3% (1/76 misclassified).

Conclusion

Use of AI to remove text from an image proved to be useful and decreased “hands-on” blinding time and variability. Proof-of-concept AI image classification model demonstrated that technology can be used to recognize 2-vessel versus 3-vessel umbilical cords in either transverse or lateral-colored images. Finally, different neural networks were tested to show one that had optimal performance in this group of images. Study is clinically important in demonstrating that AI can be successfully applied to fetal ultrasound images with low error rates providing obstetricians an additional tool to identify patients needing additional resources.