Automated Visual Evaluation (AVE) For Cervical Cancer Screening and Its Challenges

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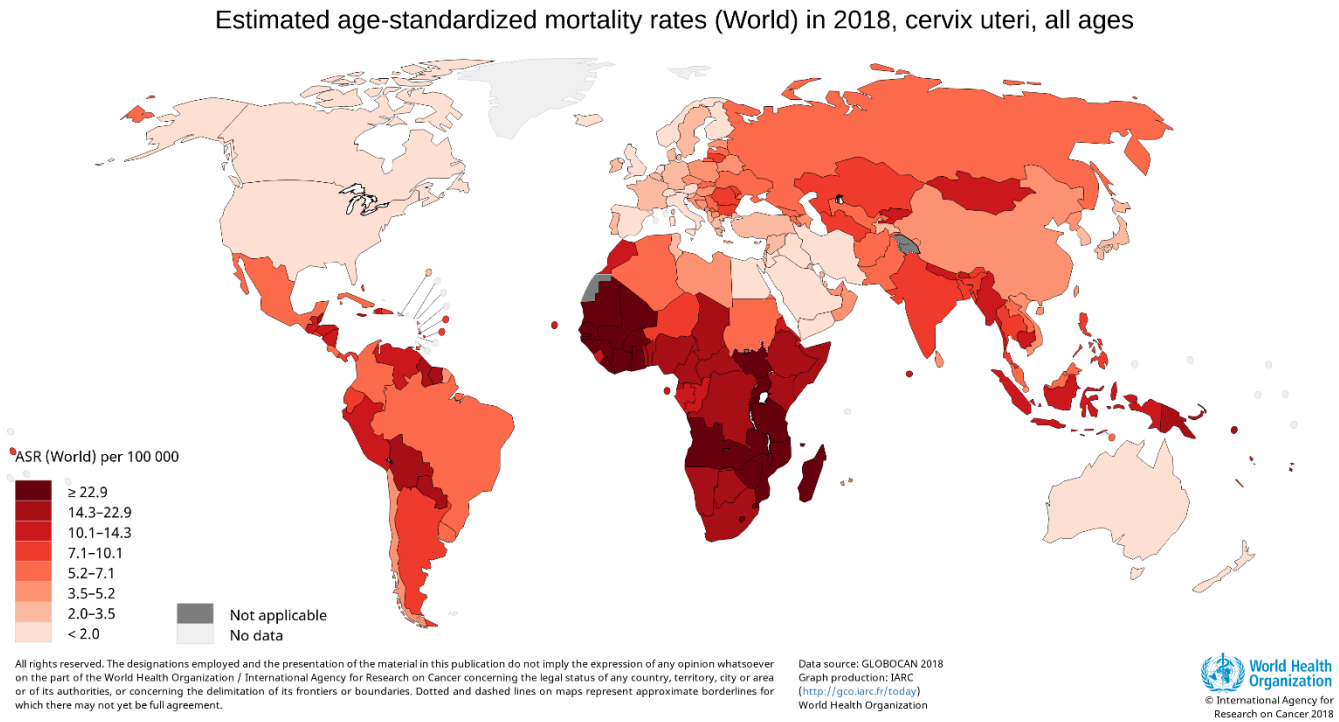
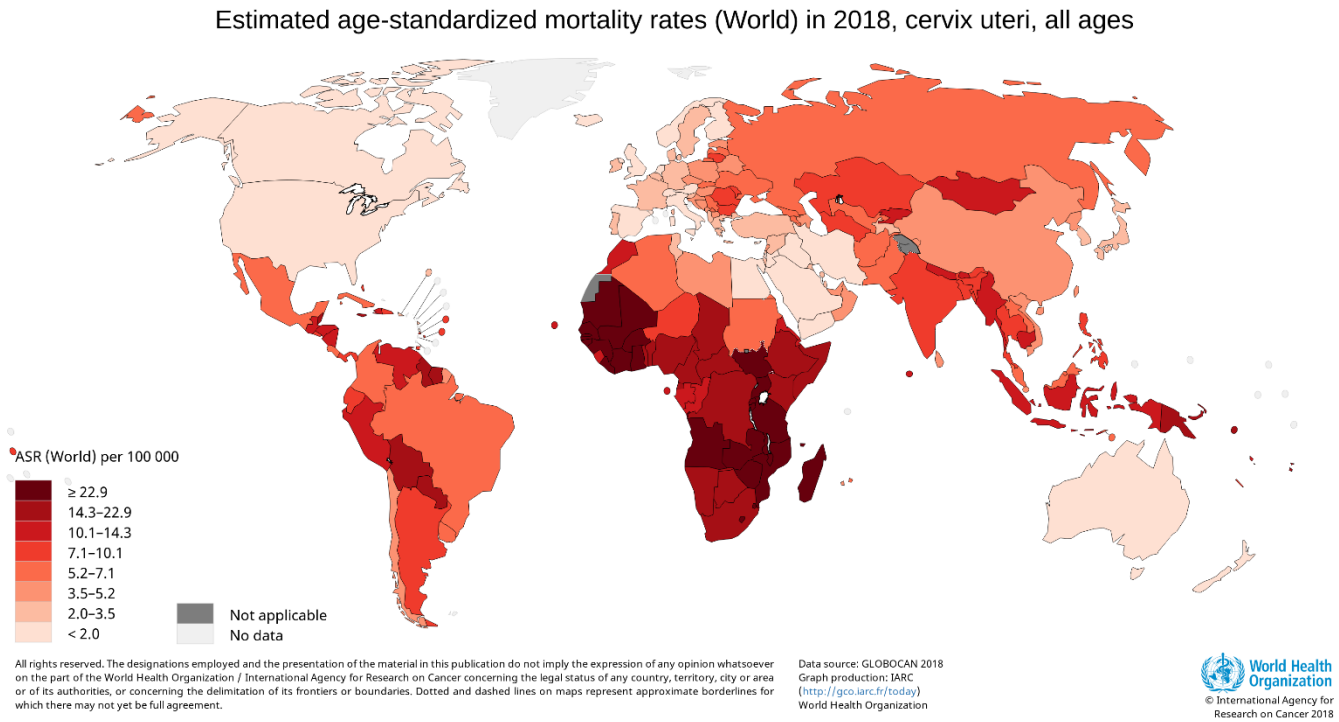
Cervical Cancer

- The 4th highest cause of cancer mortality in women
  - 570 000 new cases and 310 000 deaths in 2018
- Especially prevalent in lower resource regions
  - 90% deaths and 85% occurring in low and middle-income countries



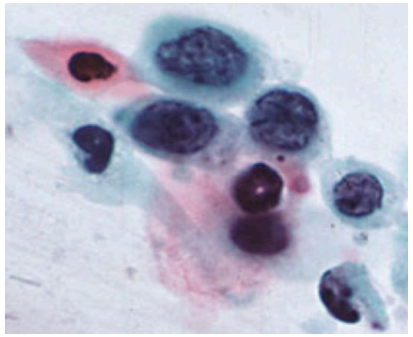
Cervical Cancer

- Caused by persistent infection of certain types of Human Papillomavirus (HPV)
  - Two HPV types (16 and 18) cause 70% of cervical cancers and pre-cancerous cervical lesions
  - HPV infection often goes away on its own
  - HPV infection can be preventable with vaccination

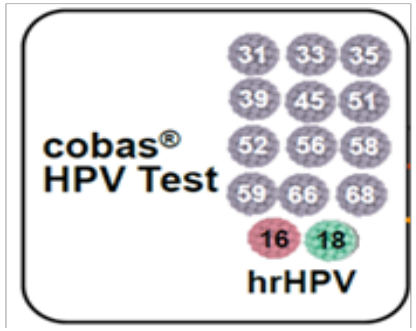


Cervical Cancer Screening

Cytology

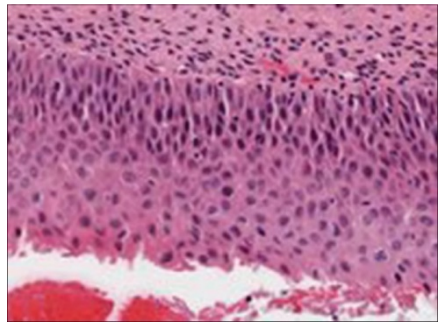


Molecular



Visual

Histology



Data Collection

Data Hosting

Analysis

Cervical Cancer Screening – Visual Inspection with Acetic Acid (VIA)

What Is VIA?

- Use bright white light to visualize cervix with unaided eye
- Clean cervix with dilute 3-5% acetic acid solution (white vinegar)
- Wait at least one minute
- Abnormal tissue temporarily appears white (acetowhite)
- Get *immediate* results
- Promotes linkage of screening with treatment

Jhpiego
an affiliate of Johns Hopkins University

NEGATIVE

POSITIVE

https://slideplayer.com/slide/6115581/

Cervical Cancer Screening – Automated Visual Evaluation (AVE)

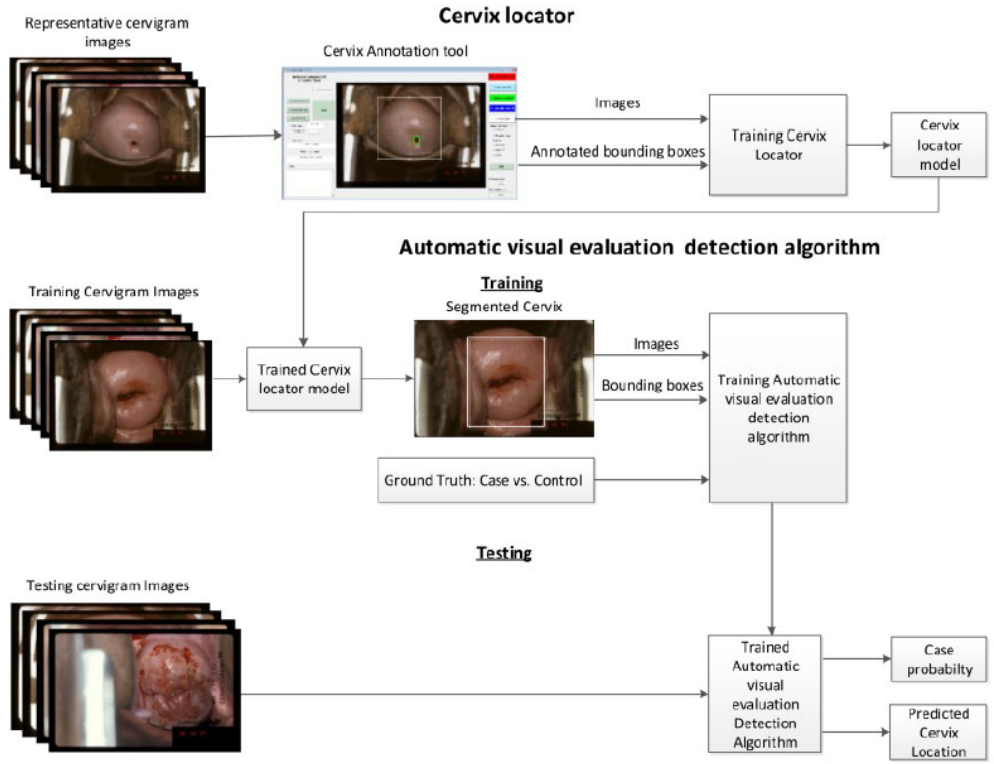


Figure 2. The system architecture of the automated visual evaluation algorithm. Two models are trained: a cervix locator (**top**), and the automated visual evaluation detection algorithm (**bottom**). The final validation algorithm incorporated both cervix locator and automated visual evaluation.

- Population-based natural history study of cervical neoplasia - Guanacaste
  - 7 year (1993 to 2001) longitudinal study conducted by NCI
  - 9400+ women
  - 60,000 cervical images (cervigrams) collected
  - Cytology, HPV, and histology results

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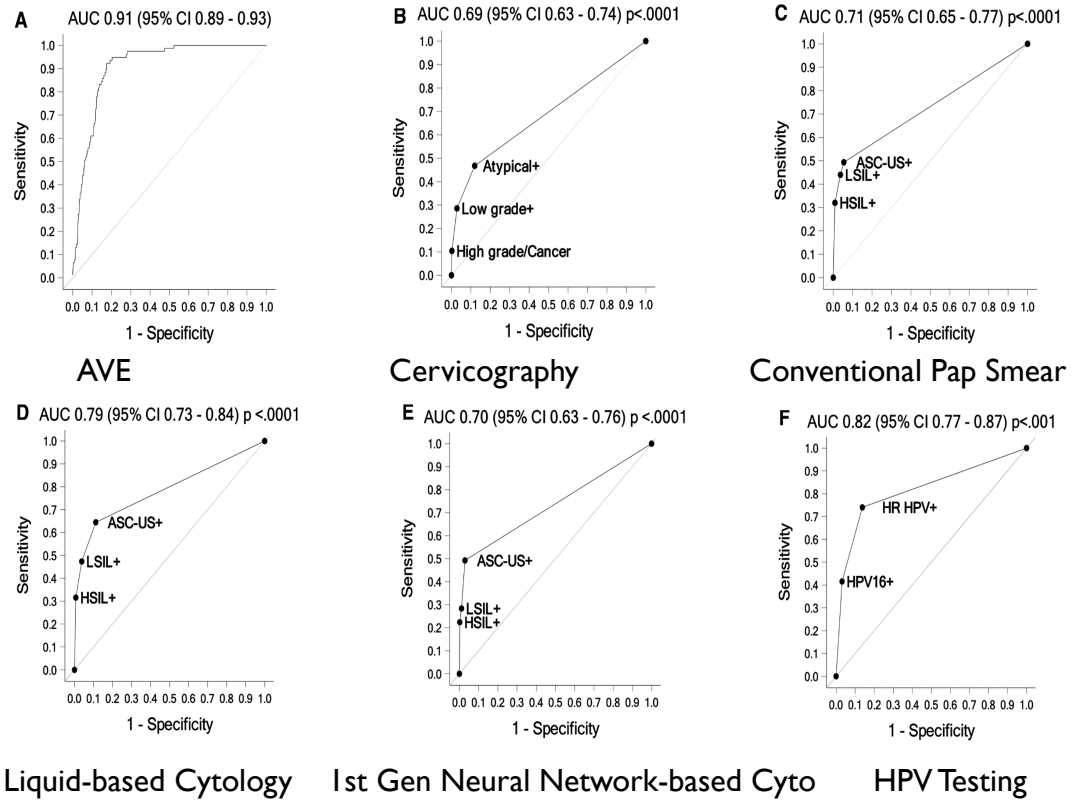
Hu L, Bell D, Antani S, Xue Z, …, Schiffman M. An Observational Study of Deep Learning and Automated Evaluation of Cervical Images for Cancer Screening, JNCI: Journal of the National Cancer Institute, Jan. 2019

Cervical Cancer Screening – Automated Visual Evaluation (AVE)



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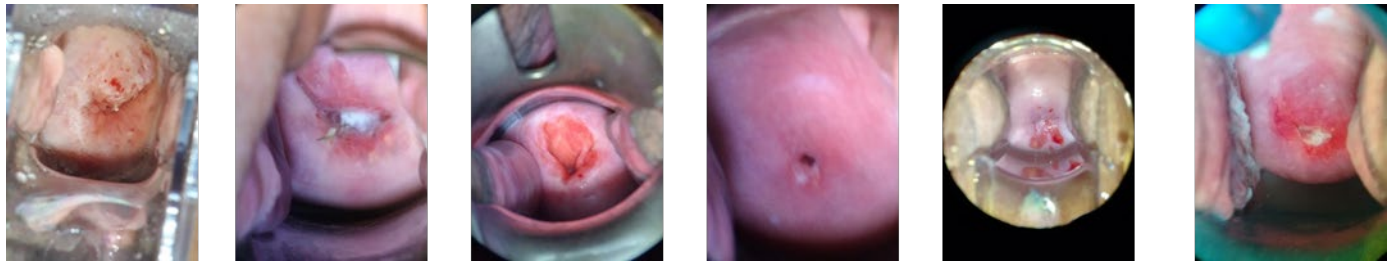
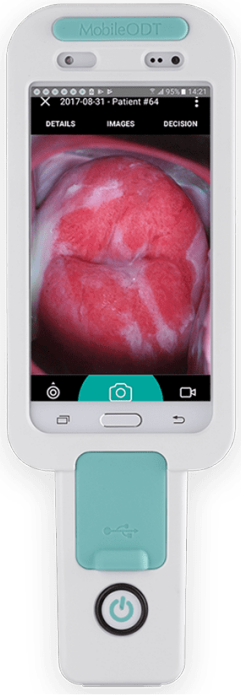
Cervical Cancer Screening – AVE using Smartphones

- MobileODT image dataset
  - Collected from clinical sites around the world using MobileODT's EVA system
  - Larger variance in image quality and many were for documentation
  - Each woman had only one visit, but multiple images





Xue Z, Novetsky AP, …, Schiffman M, Antani S. A demonstration of automated visual evaluation of cervical images taken with a smartphone camera, IJC: International Journal of Cancer, April 2020

Cervical Cancer Screening – AVE using Smartphones

- A "good set" of MobileODT dataset was evaluated by a panel of gynecologic oncologists at Rutgers University
  - Risk of having "precancer"
  - Image categories: High, Low, Medium (Uncertain and Post-Cryotherapy out)
  - Women categories (based on the categories of all her images): Low risk, Low-medium risk, Medium risk, Medium-high risk, and High risk

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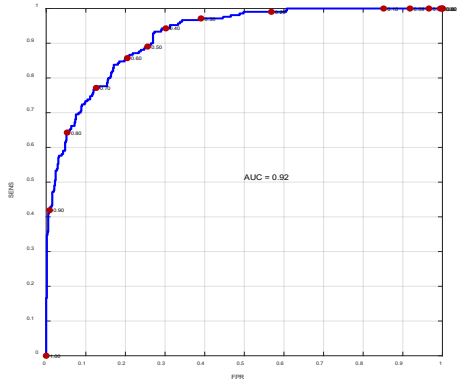
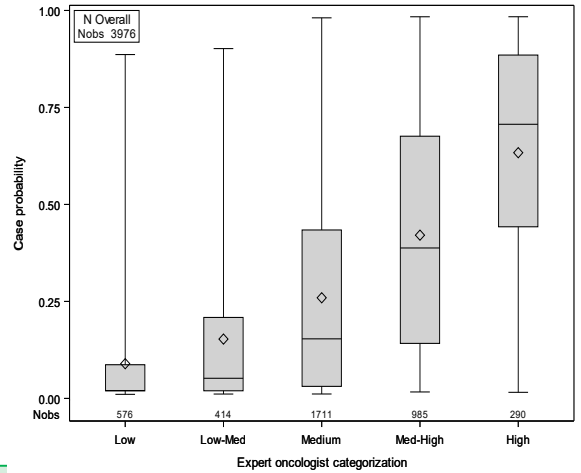
Cervical Cancer Screening – AVE using Smartphones

- Used Low risk and High risk women to train, validate and test AVE
  - Multiple random splits
  - Used two deep learning object detection networks
  - The AUC values were above 0.9 for all the ROC curves
- Also included all Intermediate (Low-med, Med, Med-high) risk women to test AVE models
- The AVE severity score were strongly associated with gynecologic oncologist impression





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Challenges for AVE

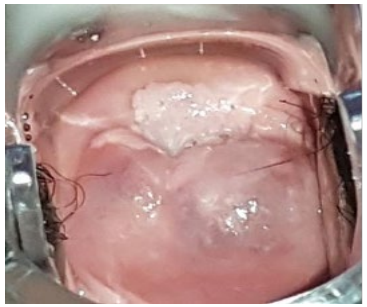
- A small amount of labeled (histopathology ground truth) dataset
- A highly imbalanced dataset (much fewer cases and a lot more controls)
- Robustness of AVE for image variabilities across multiple devices
- Image quality control and its influence on the AVE algorithm
- Selection of AVE cutpoint and adjustment of AVE scores

Challenges for AVE – Variability Across Devices

Samsung S8 cellphone

MobileODT EVA

Colposcope with Nikon camera



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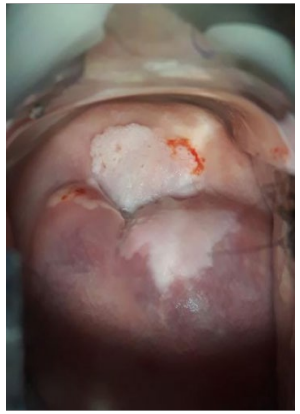


MobileODT EVA

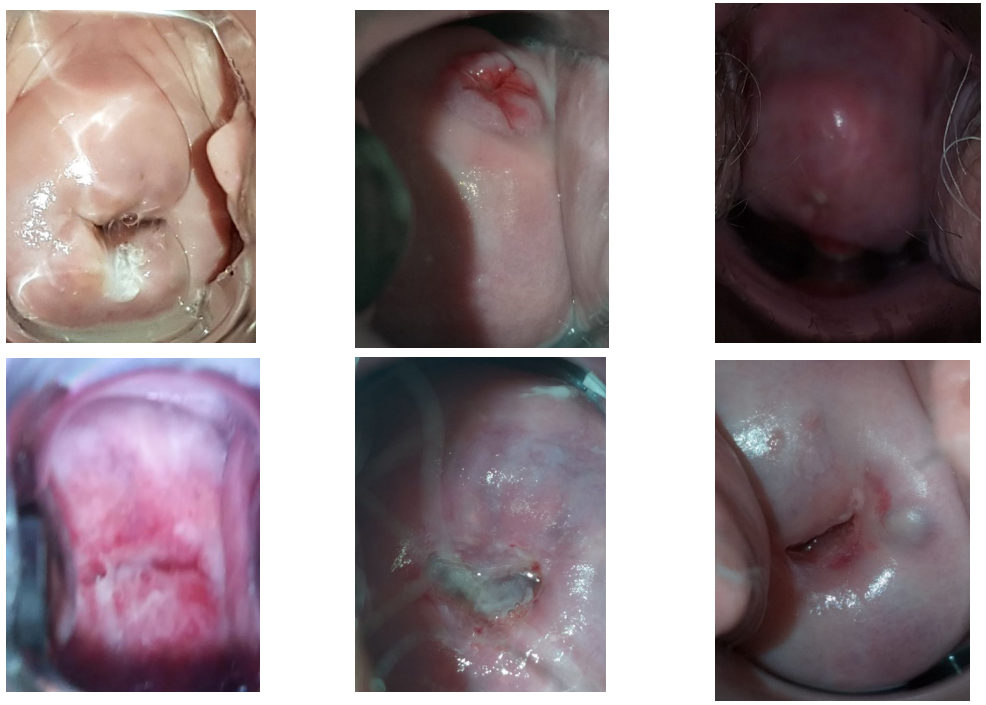
Colposcope with Nikon camera

Motorola G3

Samsung J530

Challenges for AVE – Image Quality

- Glare on the image
- Shadow
- Blur (shake, motion, digital magnification)
- Focus
- Occlusion and cervix visibility



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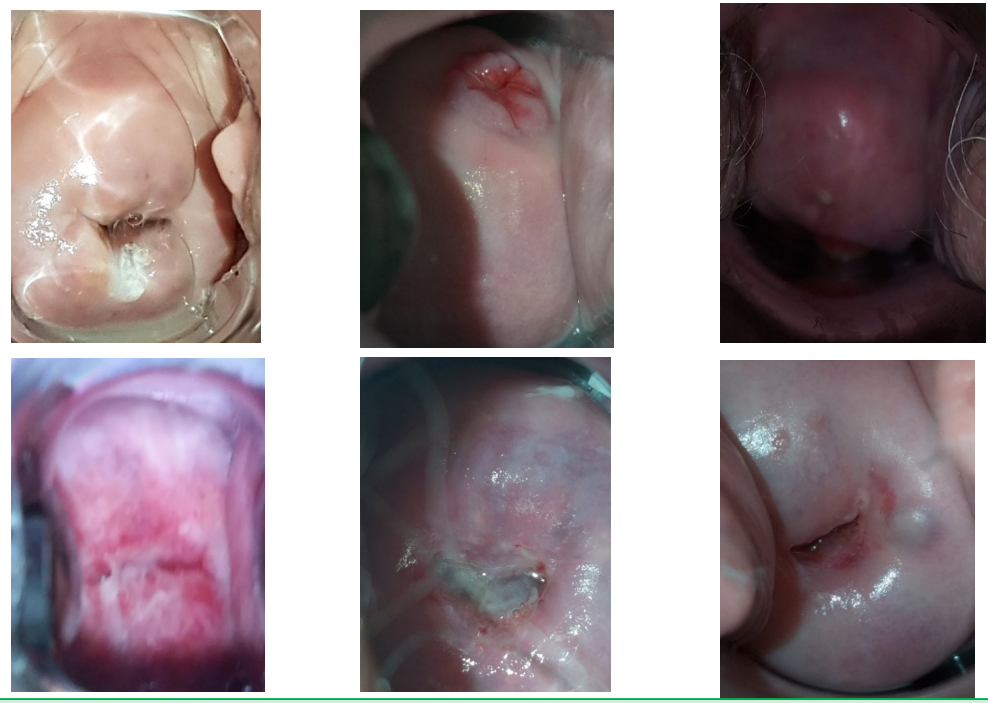
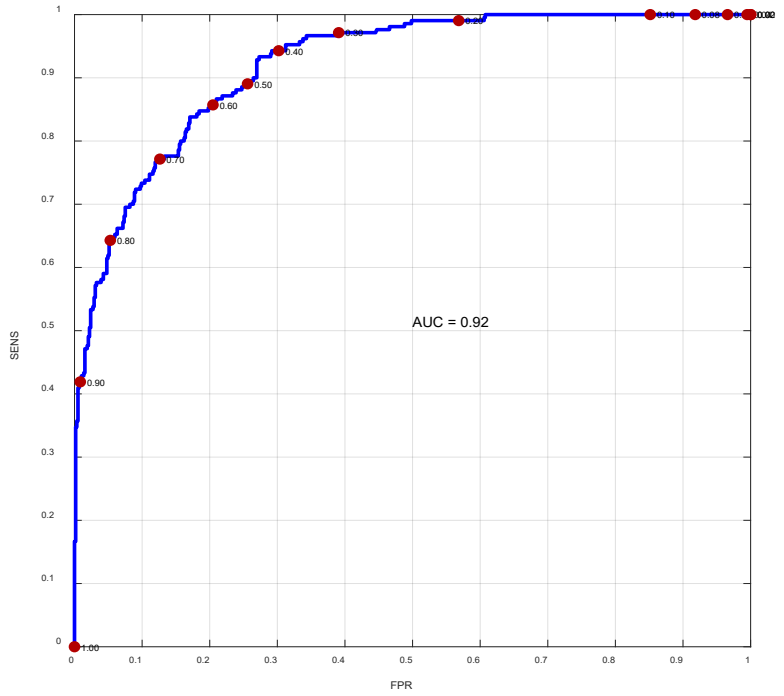


Guo P, Singh S, Xue Z, Long LR, Antani SK. Deep Learning for Assessing Image Focus for Automated Cervical Cancer Screening. IEEE EMBS International Conference on Biomedical & Health Informatics (BHI), May 2019

Ganesan P, Xue Z, Singh S, Long LR, Ghoraani B, Antani SK. Performance Evaluation of a Generative Adversarial Network for Deblurring Mobile-phone Cervical Images. IEEE Engineering in Medicine and Biology Conference (EMBC), July 2019

Guo P, Xue Z, Mtema Z, …, Schiffman M, Antani SK. Ensemble Deep Learning for Cervix Image Selection toward Improving Reliability in Automated Cervical Precancer Screening, MDPI Diagnostics, July 2020

Challenges for AVE – AVE Score Cutpoint Selection and Adjustment



Conclusions

- AVE offers a great opportunity to address an important women's health problem
- Insight into clinical practices, health data acquisition, and gaps are key to identifying creative opportunities for intelligent automation
- Addressing challenges such as dataset size, variety, and quality are key to obtaining reliable results