Artificial Intelligence Based Spontaneous Preterm Birth Prediction Using Ultrasound and EMR Data

Alicia B Dagle, MS[1], Yucheng Liu, MS[2], Erin M. Louwagie, MS[1], Qi Yan, PhD[3], Kristin Myers, PhD[1,4], Sachin Jambawalikar, PhD[2,4]

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MOTIVATION

Preterm birth affects 1 in 10 births worldwide and is the leading cause of infant death. Surviving infants are at an increased risk of lifelong disabilities. The prediction and prevention of preterm birth remains an important, unsolved problem.

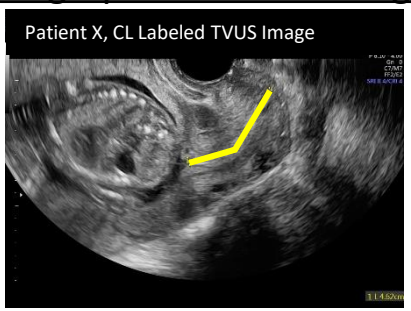
image source: https://www.infirmiers.com

- Spontaneous preterm birth (sPTB) is defined as early labor and delivery before 37 weeks gestation
- The mechanical role of the cervix in supporting the developing fetus is not yet well understood

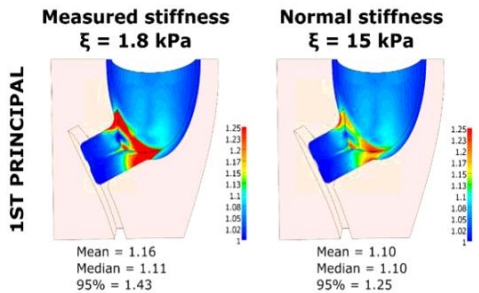
Cervical length is insufficient to predict sPTB

- The clinical gold standard is less than 60% sensitive to sPTB detection, and is an incomplete picture of cervical health.
- Shape and material properties are also important

Sonographic Cervical Length



Material Properties



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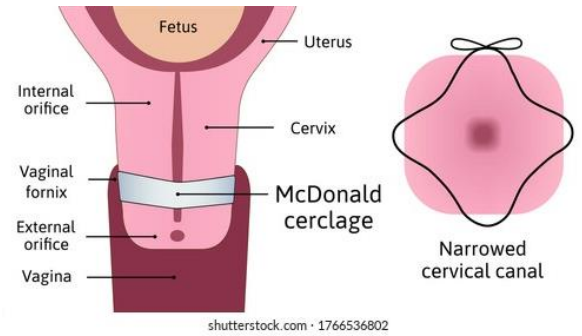
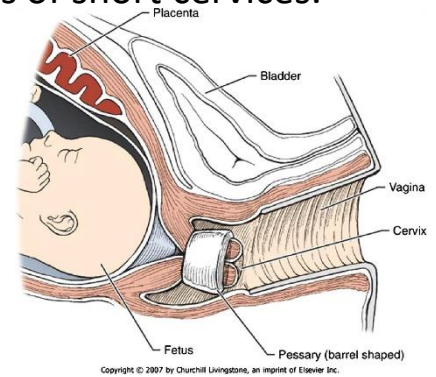
Current Treatments Fall Short

- Cervical cerclage and pessary placement are not sufficient to prevent spontaneous preterm birth (sPTB) for patients with history of sPTB or incidental findings of short cervices.





Improved understanding and early detection will enable better patient care

Hypothesis: A multi-faceted approach using complex geometries of the cervix will outperform cervical length alone for prediction of spontaneous preterm birth (sPTB).

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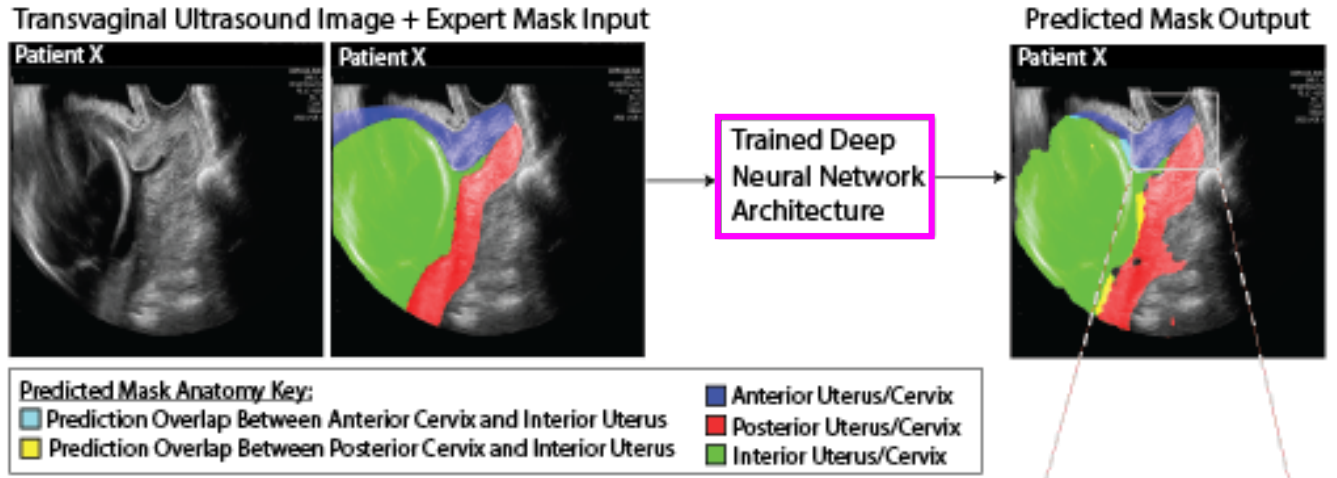
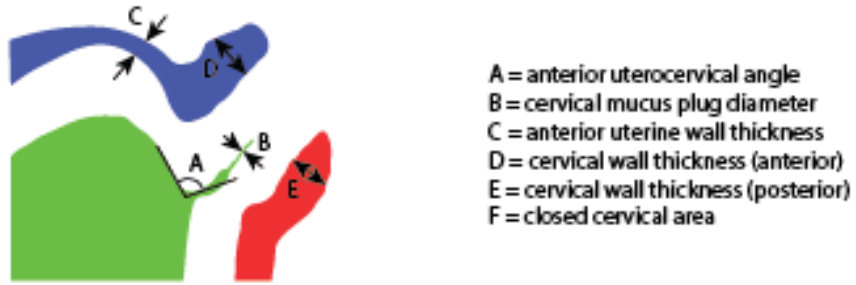
METHODS

Research Objective: The development of a high-throughput method for extracting cervical geometry of individual patients will stratify prediction and understanding of spontaneous preterm birth (sPTB).

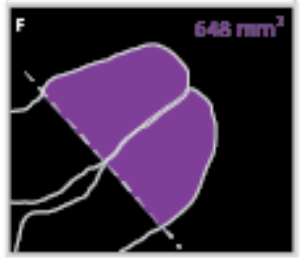
1. Collect Ultrasound Images and Electronic Medical Record Data to Train Algorithm



2. Geometric Feature Extraction of Uterocervical Support Structure

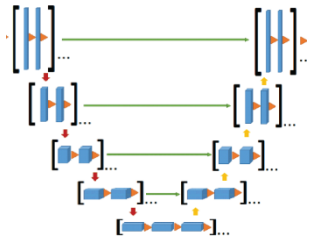


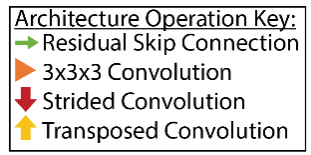
A = anterior uterocervical angle
B = cervical mucus plug diameter
C = anterior uterine wall thickness
D = cervical wall thickness (anterior)
E = cervical wall thickness (posterior)
F = closed cervical area



Trained Deep Neural Network Architecture:

- 2D UNet CNN





- DeepLabV3 CNN
  - Multiclass segmentation

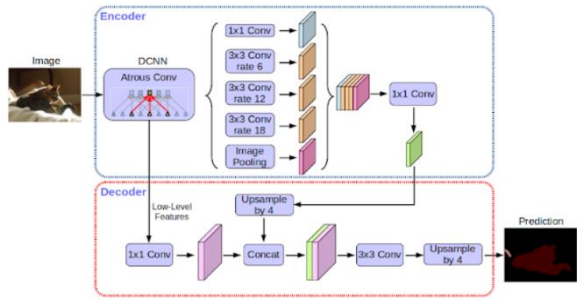


image taken from https://ai.googleblog.com/2018/03/semantic-image-segmentation-

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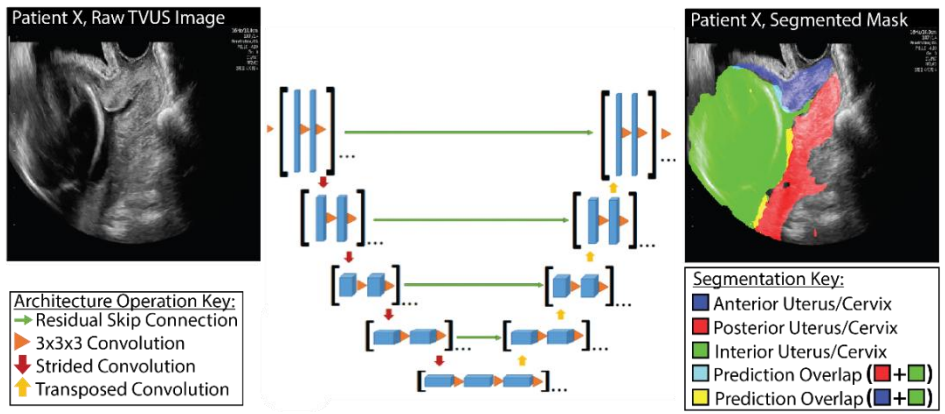
RESULTS & FUTURE WORK

Preliminary results of patient-specific anatomical geometries are promising. After further refinement, we will combine cervical geometry with raw image and patient EMR data to stratify birth outcome predictions. Robust geometry extraction will also be used to inform more accurate 3D models for Finite Element Analysis (FEA) of mechanical loading during pregnancy.

Preliminary Dataset & Results:

- 47 patients, 60 images (multiple time points)
  - 50 train, 10 validation
- ~ 25% incidence PTB among patients

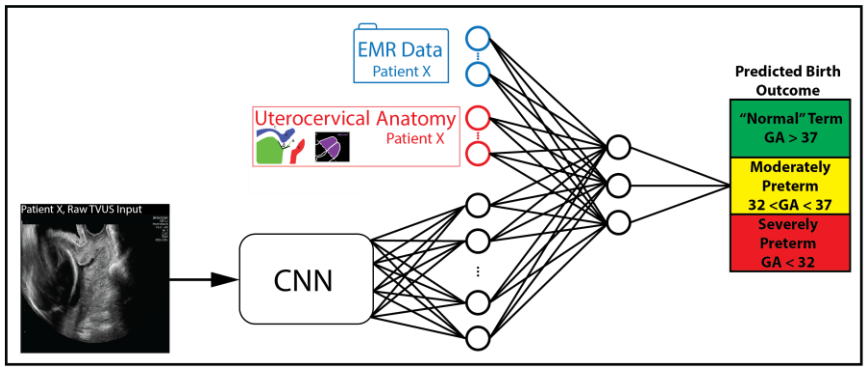
Promising Preliminary Results with ResUnet Architecture



- Next Steps: collect > 1000 patient images, expert segmentations & EMR data; retrain multiclass network to eliminate overlapping regions and improve geometry extraction

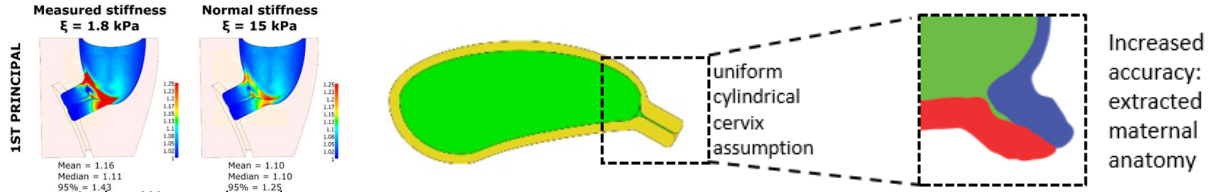
Future work:

- Combining images, extracted geometries, EMR data and other biological markers to predict birth outcome



- Extracted cervix geometries can inform FEA models of pregnancy

Parametric FEA models of cervix may be improved upon with more precise cervical geometry



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