

# Texture Analysis in Cervix Optical Coherence Tomography Images of Pregnant and non-Pregnant Women

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## INTRODUCTION

- Pre-Term birth (PTB) is a dangerous complication that can occur during pregnancy. Previous studies have shown that PTB is linked to premature cervix remodeling.
- Optical Coherence Tomography (OCT) is a noninvasive imaging technique that works by reflecting light waves off of an area of the body to identify the depth of the cervix, and using that data to produce a 2D reconstruction of the cervix
- This experiment aims to examine OCT images of axial cervix slices and examining the collagen matrix of the cervix to see if cervix remodeling can be identified
- OCT images were taken from pregnant and non-pregnant women, and the images were compared to see if it was possible to differentiate the cervix slice images of pregnant and non-pregnant women
- Study found that pregnant cervix specimen had higher fiber dispersion and more heterogeneous fiber properties than non-pregnant cervix specimen

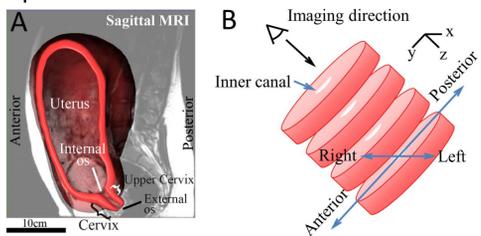


Fig. 1. A: Anatomical position of uterus and cervix at 22 weeks. B: Illustration of specimen preparation in upper cervix.

## METHODS

- 13 human cervixes collected from consenting hysterectomy patients: 11 non-pregnant women undergoing hysterectomies, and 2 pregnant women undergoing Cesarean hysterectomies
- Cervixes sliced into sections with 3mm-5mm thickness immediately after hysterectomy

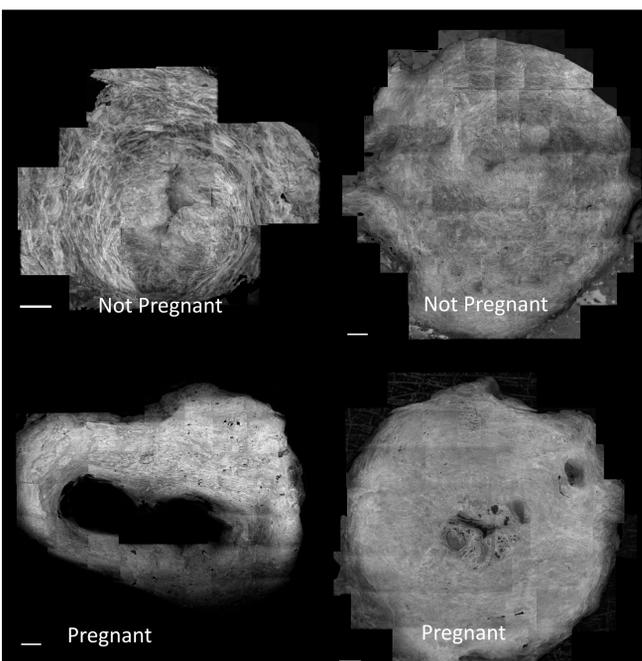


Fig. 2. 5µm X 5µm Specimen OCT images taken in the study. Note that pregnant specimen have a more heterogeneous fiber pattern.

- 3D data stitched from shift invariant feature in camera image within en face plane and OCT axial data, from this info parallel en face image 245µm below the surface was generated
- Fiber orientations extracted for every pixel, collagen region masked based on signal-to-noise ratio
- Image enhanced with histogram stretching, sharpened with second order Butterworth high pass filter, denoised with median filter
- Weighted summation scheme used to find fiber orientation at each pixel

## RESULTS

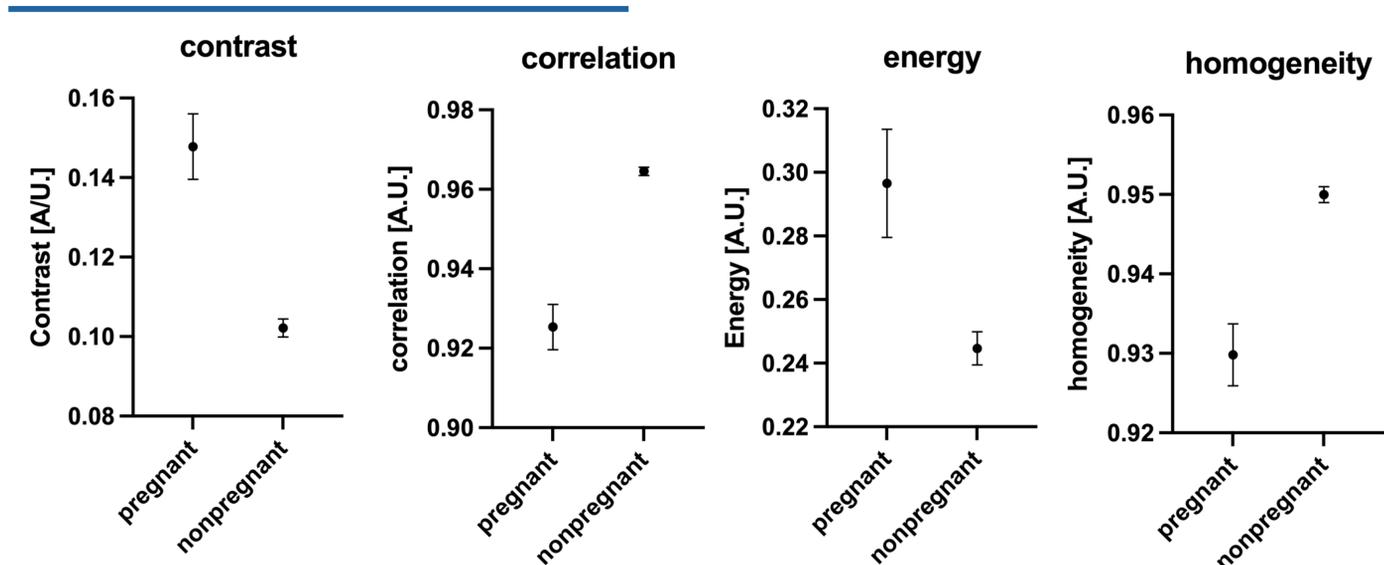


Fig. 4. Shows the mean +/-95% confidence interval for each texture feature. t-tests were conducted and all features were statistically different between pregnant and nonpregnant specimen, with p<0.001 for all textures

## TEXTURE ANALYSIS

- Image loaded into MATLAB filter, segmented into 20x20 grid
- In each segment, average filter applied, Gray Level Co-Occurrence matrix (GLCM) generated
- Properties of GLCM (contrast, correlation, homogeneity, energy) found, color map for each property generated for each image
- Constructed histograms and scatter plots to compare properties for pregnant and non-pregnant women

$$\sum_{i,j} |i-j|^2 p(i,j) \quad \sum_{i,j} \frac{(i-\mu_i)(j-\mu_j)p(i,j)}{\sigma_i\sigma_j} \quad \sum_{i,j} p(i,j)^2 \quad \sum_{i,j} \frac{p(i,j)}{1+|i-j|}$$

Contrast      Correlation      Energy      Homogeneity

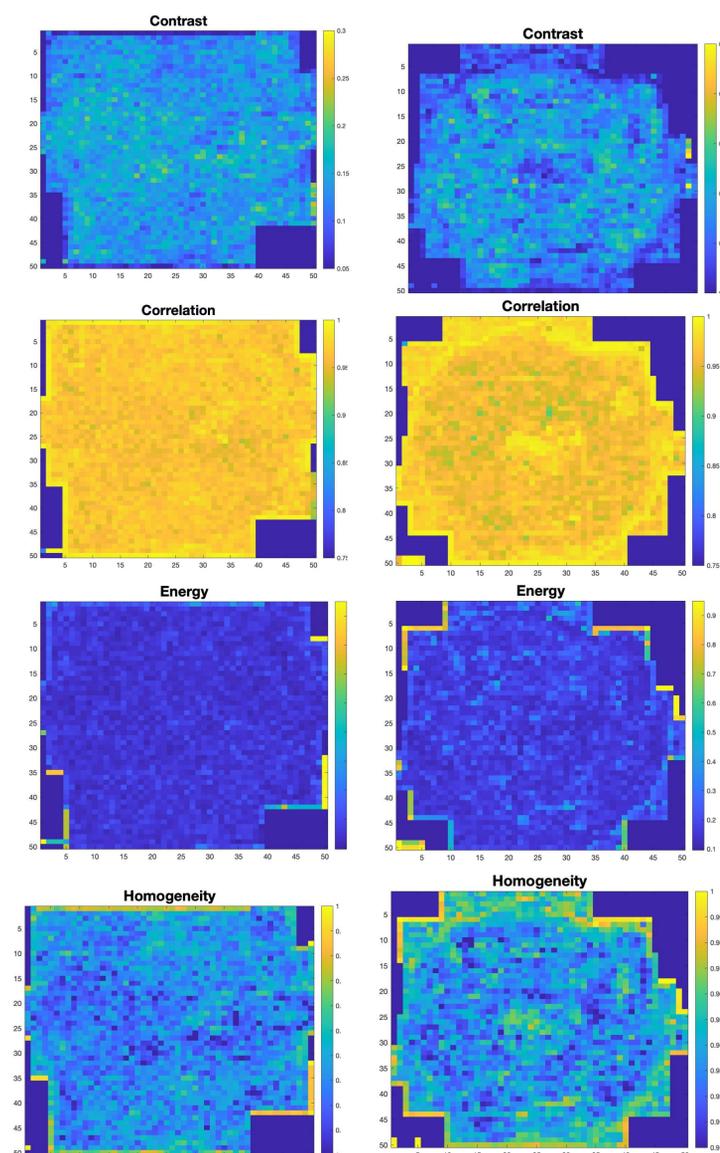


Fig. 3. Texture analysis colormaps of Specimen 5 (not pregnant)(left) and specimen 13(pregnant)(right). You can see a clear difference in the values for pregnant and no-pregnant specimen for all four properties

- Significant difference between all 4 texture features
- Can see difference in colormaps

## DISCUSSION

Texture analysis shows that these texture features are statistically different. In order to differentiate between them, we will need a model. By itself, correlation has the highest difference, with an AUC of .71 for the receiver operator curve. For a classification algorithm, additional features can be combined together including fiber orientation dispersion, optical properties such as the attenuation coefficient, and texture features.

## FUTURE WORK

The end goal of this research is to find a way to identify the remodeling of the cervix that comes immediately after birth, and using those methods to predict pre-term birth. In order to learn more about these markers, it is important to get a larger sample size of OCT images of pregnant and non-pregnant cervix specimen to verify the results. Another way to advance the research is to try to apply other image processing filters such as the entropy and range filters and seeing if it is possible to identify pregnant cervix images from these specimen.

## REFERENCES

1. Wang Yao, Yu Gan, Kristin M. Myers, Joy Y. Vink, Ronald J. Wapner, Christine P. Hendon. Collagen Fiber Orientation and Dispersion in the Upper Cervix of Pregnant and Non-Pregnant Women. PLOS. 2016
2. Yu Gan, Wang Yao, Kristin M. Myers, Joy Y. Vink, Ronald J. Wapner, Christine P. Hendon. Analyzing three-dimensional ultrastructure of human cervical tissue using optical coherence tomography. Optica publishing Group. 2015

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