Development and Application of a Method to Establish Pressure-Strain Calibration Curves for Cell Stretching Systems

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Abstract/Introduction

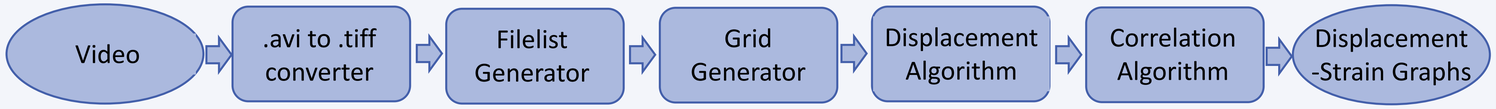
The Flexcell FX-4000™ Tension System is a patented, computerized, and pressure-operated instrument that applies a defined and controlled duration of cyclic tension to cells attached to a deformable membrane *in vitro*. A modified version of the Flexcell system with custom components is being used in our lab, but the strains exerted on the membrane in the modified set up have yet to be characterized. The goal of this project is to develop and apply a method to characterize the membrane strains applied in the modified system. Our approach involves using pre-existing strain calculation algorithms that are being modified to suit the Flexcell system, as well as a bio-image analysis tool developed to analyze videos of the membranes undergoing deformation. Currently, a plugin is being developed for the interface and algorithm of a bio-image analysis software called Icy. The plugin detects and tracks five spots that are marked on the membranes. An algorithm determines the strain in certain regions based on displacement of the tracked spots and calculates the resulting strain field in the membrane as a function of the applied pressure. The pressure-strain calibration curves will be used to enable application of physiological and superphysiological strains to heart valve cells to test the hypothesis that excessive strain associated with high blood pressure causes disease development in heart valve cells.

Objective

To develop a method to establish pressure-strain calibration curves for the cell stretching system. This method should be:

- Accurate
- Easy to use
- Fast

Methods



Input	Converts the video into multiple images	Identifies the images to process	Generates a grid on all the images for tracking	Tracks the displacement of every grid point with respect to its neighboring points	Finds the strain on the grid based on the displacements of grid points	Output

Figure 1: Steps involved in the current method.

The five complicated steps mentioned above will be replaced by two simple steps by automating the grid generation and application of the displacement and correlation algorithms. This can be done because the size and placement of the grids is the same for all the videos in our research and the intermediate data between the application of the algorithms is not useful.

Results

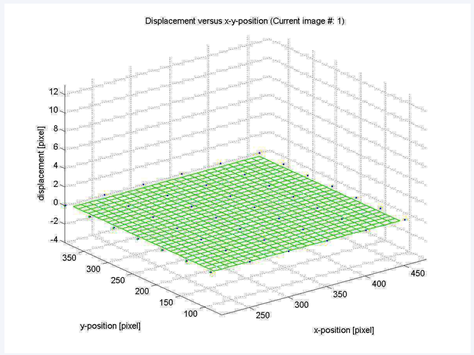


Figure 2: Initial stage (8% elongation). The region plotted in these meshes is the area above the loading station posts. The points on the mesh are the grid points generated by the algorithm.

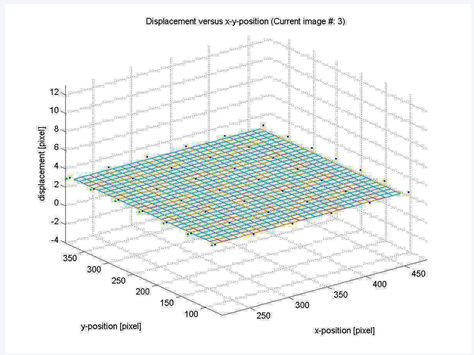


Figure 3: Intermediate stage (10% elongation). The flat mesh implies that the displacement is equal along the x and y axes.

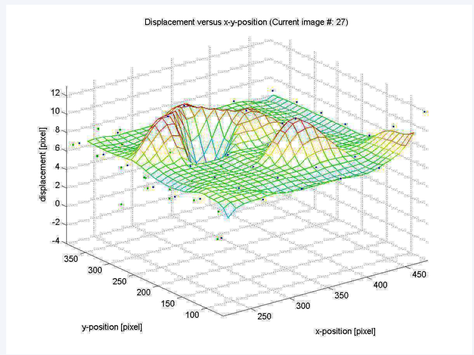


Figure 4: Maximum strain (14% elongation). The peaks are caused due to reflection on the surface of the membranes and air bubbles between the posts and the membranes. These factors will be eliminated by eliminating reflection in the videos and by adding vacuum grease between the posts and the membranes.

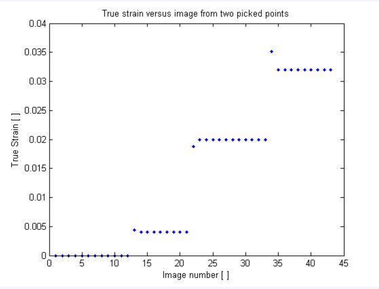


Figure 5: Strain between two points selected by the user on the membrane. The image number represents the frame number in the video. We can notice in this case that the true strain is increasing with time between the selected points.

Discussion

- The data from the Flexcell system will be integrated with the available results to obtain pressure vs strain graphs.

Future Work

- The pressure-strain calibration curves will be used to enable application of physiological and superphysiological strains to heart valve cells to test the hypothesis that excessive strain associated with high blood pressure causes disease development in heart valve cells.
- This method can be used to find the strain curves for any system regardless of the size of the stretching membranes.

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