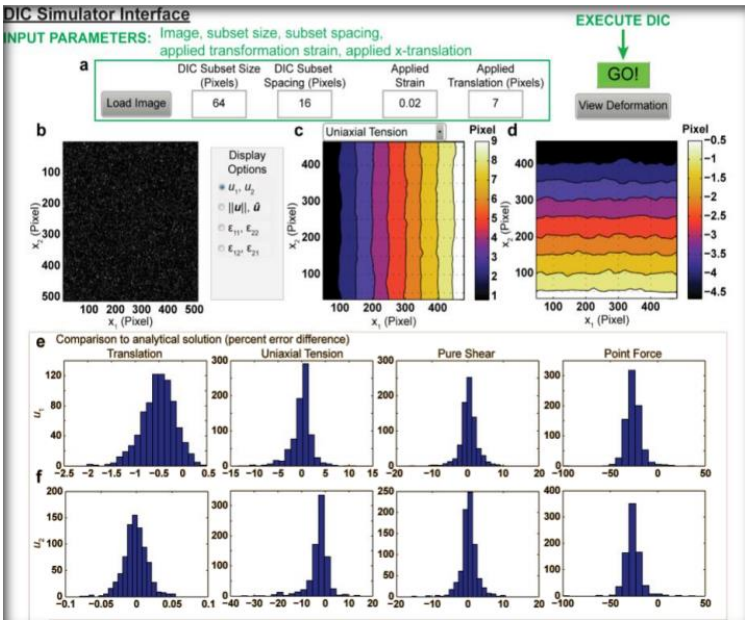
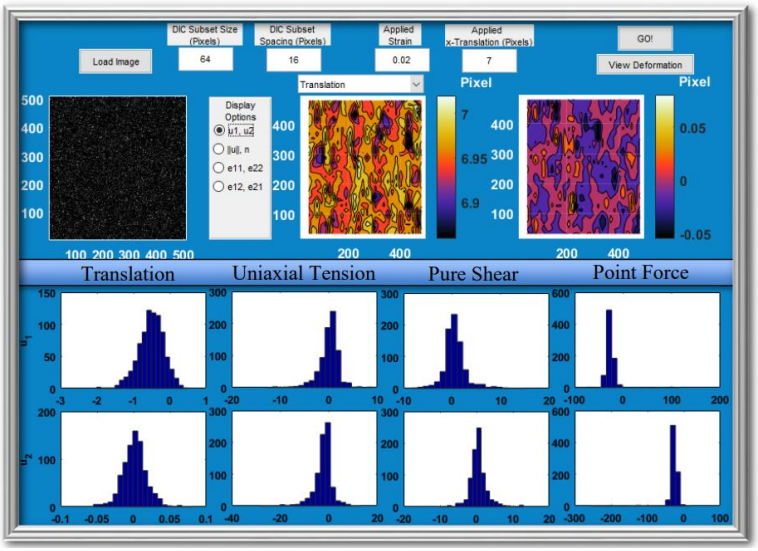
Speckle pattern summary

- Our lab performed DIC on slices of images from a gel – like substance filled with cells to produce the deformation field.
- DIC essentially performs second order deformations about each subset of the original image and tries to cross correlate it with the deformed image (first order deformation are superposition of translation, uniaxial tension, shear). Since the algorithm does this for a large combination of deformations on each subset, it takes a lot of time to run a full scale DIC analysis (maybe days), so there is a need to evaluate how good the speckle pattern is before performing the analysis.
- Took an article which implemented an algorithm to perform a speckle pattern check. The algorithm basically performed **deformations**: translation, uniaxial tension, shear and point force (individually) on the **entire image** and tried to recover the deformation field using subset correlation of the original image (without deforming it) **on a relatively small portion of the image around the specific subset**. For relatively small deformations this can be done quite accurately.





- Correlation calculation:

בהינתן שתי תמונות: A ו- B, המיוצגות כמטריצות באופן בו הוסבר לעיל, נוכל להגדיר את הפעולה:

$$CrossCorrelation^{Local}(A,B): \mathbb{M}^{n\times m\times b} \times \mathbb{M}^{n\times m\times b} \to \mathbb{R}$$

באופן הבא:

(1) $CrossCorrelation^{Local}(A,B)$:

$$= \sum_{i,j,k=1}^{X_{pixels},Y_{pixels},Z_{pixels}} \frac{(A(i,j,k)-\bar{A})\cdot(B(i,j,k)-\bar{B})}{n\cdot\sigma_A\cdot\sigma_B}$$

כאשר בנוסחה (1): $n = X_{pixels}\cdot Y_{pixels}\cdot Z_{pixels}$,

$\bar{A}$ ו- $\bar{B}$ הם הממוצעים החשבוניים של דרגות האפור בתמונות A ו- B בהתאמה.

כך למשל עבור A:

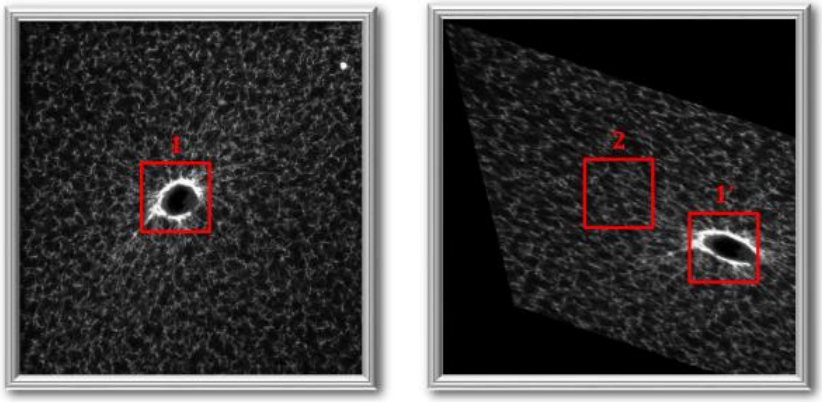
$$\bar{A} = \frac{\sum_{i,j,k=1}^{X_{pixels},Y_{pixels},Z_{pixels}} A(i,j,k)}{n}$$

וכן σ_A ו- σ_B הם סטיות התקן של הערכי האפור במטריצות A ו- B בהתאמה.

כך למשל עבור A:

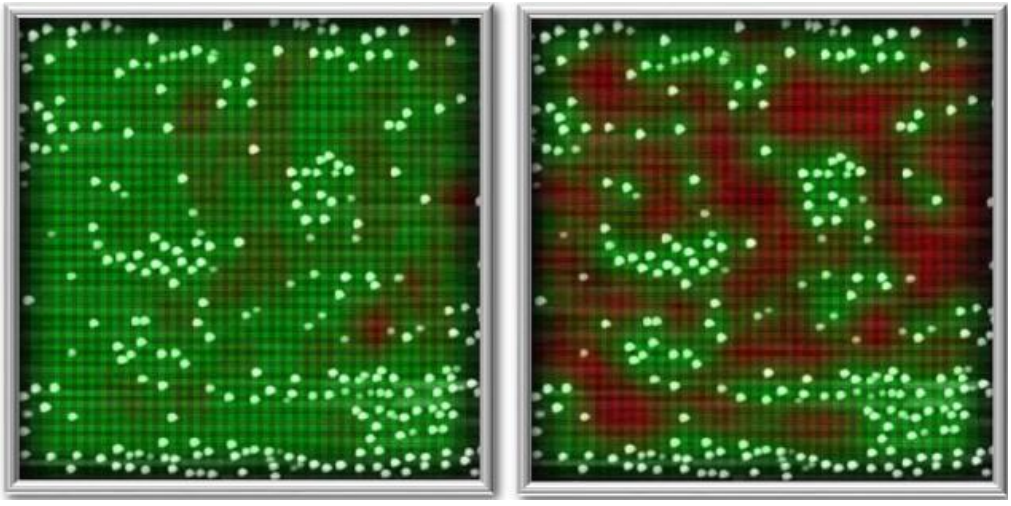
$$\sigma_A = \sqrt{\sum_{i,j,k=1}^{X_{pixels},Y_{pixels},Z_{pixels}} \frac{(A(i,j,k)-\bar{A})^2}{n}}$$

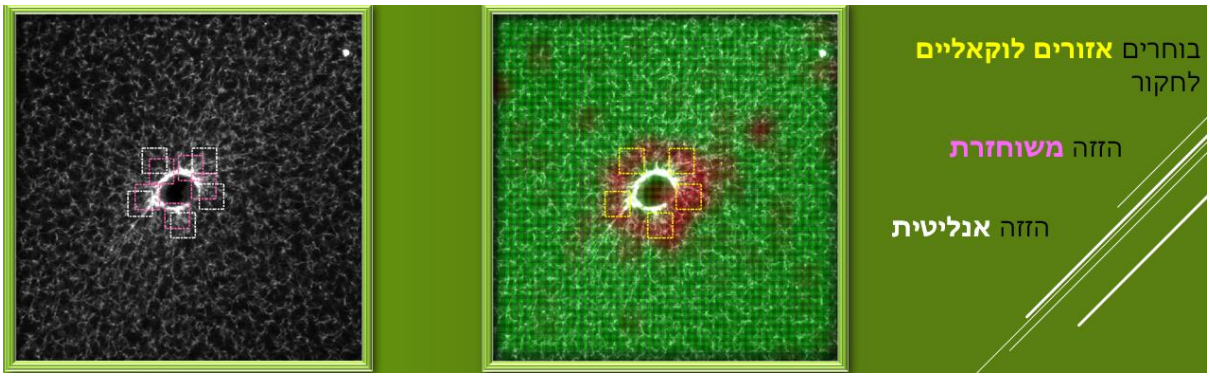
- The deformation field is recovered from the correlation of each subset within the image. Each subset deformation is taken to be the place with the highest correlation. For this to work we need an image with variety and a **unique** speckle pattern.
- We studied the article's algorithm and found several problems we can improve on as well as new ideas we can implement.
    - The image after deformation is kept at the same size as the original image. This may lead to large areas of absence in the resulting image, in our approach we made sure to allow variable size output of the deformed image.
    - Inability to apply several deformations at once (as should be more than expected to happen in real life deformation field reconstruction). We solved this by allowing an **affine deformation** to the image which includes the superposition of several standard deformations at once.
    - Limited "search area" for each subset within the deformed image:



We solved this problem by allowing a greater search area defined by the "extend" parameter set by the user. A new use for this tool was also implemented as will be elaborated upon shortly.

- We performed several analyses comparing two common types of speckle patterns used in the lab, depending on the different parameters the algorithm uses to give a suggestion of preferred speckle pattern.
- The "extend" tool allows to recover the deformation field and performed better correlation at larger deformations.
- We found a unique use of this tool, to allow the user to see the problematic areas within the speckle pattern (those lacking in information and variety). Because better correlation can be performed under large deformations using the extend tool, we can uncover areas in the speckle pattern that aren't correlated well the resulting image: **(since by enlarging the search area we can discovers areas which aren't uniquely correlated and can be "mistaken" with other similar areas in the image):**





- Our implementation interface