E4: Optical Strain Measurement Using Digital Image Correlation

1. **Objective:**

   Non-contact full-field strain measurement in tensile metal samples using image correlation

2. **Theory/Background (related to the experiments)**

   This technique starts with a picture before loading (reference image) and then a series of pictures are taken during the deformation process (deformed images). These images are then compared to detect displacements by searching a matched point form one image to another. Here, because it is almost impossible to find the matched point using a single pixel, hence an area with multiple pixel points is used to perform matching process. This area is naturally called as subset. The subset has a random gray level (light intensity for optical monochrome images) distribution of pixels, but it lends a unique identity to the subset. It is assumed that this light intensity does not change during deformation. However in practice, the light intensity may vary during experimentation. The numerical algorithm is usually equipped to handle any offsets or linear variations in the light intensity. The displacement of the subset is found out by searching the area of same light intensity distribution with the subset. Once the location of this subset in the deformed image is found, the displacement can be determined using simple Euclidean distance formula. In order to perform this process, the surface of the object must have a feature that allows matching the subset. If no feature is observed on surface of object, an artificial random pattern must be applied (as shown in fig 2).

   To evaluate the similarity degree between the reference subset and the deformed subset, a crosscorrelation (CC) criterion is used. The criterion measures how closely a certain area in the deformed image resembles that of the subset. The matching process is finished by looking for the highest point in the correlation coefficient distribution. Once the correlation coefficient extremum is detected, the position of the deformed subset is determined. The in-plane displacement vector at point P is produced by the differences in the locations of the reference subset centre and the target subset centre, Keep in mind that the pixel or point of interest is expected to be in the field of vision for both the before and after distortion in this calculation of displacement.

3. **Equipment Required:**
   (a) Digital camera
   (b) appropriate optical lens
   (c) computer
   (d) Al sheet specimen pattern generating apparatus
   (e) Vernier calipers
   (f) tripod

4. **Experimental Method:**
   (a) First, paint the surface with a thin layer of white paint (it could be spray paint) and then apply a black mist of paint (spray paint) to create the black speckles.
   (b) After the sample is prepared and the universal testing machine is configured, select an accessible position for the digital camera and adjust the focal length to fix and acquire a clear image.
   (c) Set the aperture range of the camera lens with the lowest f-number as possible to let the entrance of the maximum amount of light. The illumination has to be appropriate.
   (d) Hold a measuring scale vertically and attached to the surface of the deforming body. Acquire an image in this position and observe the scale divisions spanning the image length. Assuming, x mm. of the measuring scale covers y pixels of the image, a simple linear calibration yields x/y mm/pixel

5. **Expected outcomes:**
   (a) Speckle pattern generation and its histogram.
   (b) Obtain experimental data, viz., images of the sample surface during deformation and load vs. time plot.
   (c) Construct stress vs. strain curve using the load vs. time and strain (calculated using DIC) vs. time.
   (d) Compare the Young's modulus from the experiment and the material data sheet.
   (e) Plot and show that there is uniform strain on the surface of the sample at various load levels….