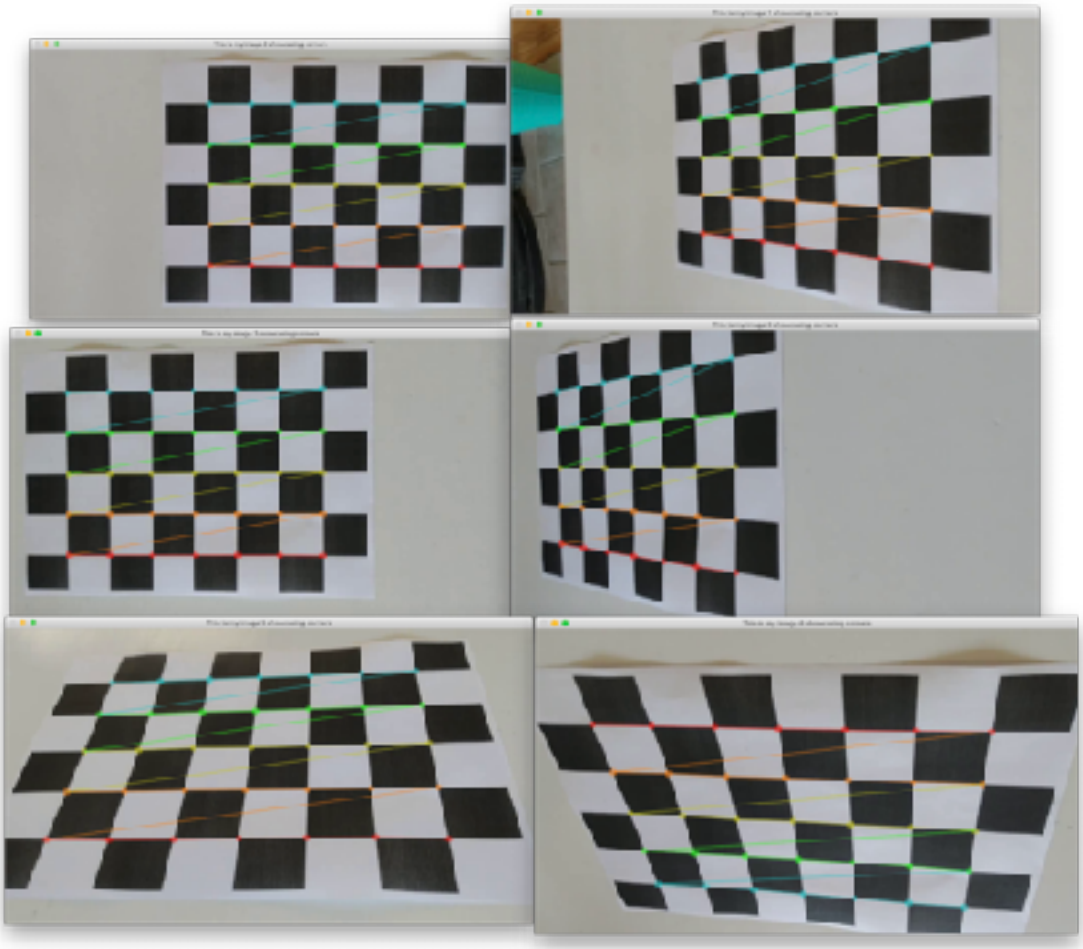
Machine vision ass02-

(This pdf showcases the output received for all the parts)

Task 1-

- Download the file **Assignment_MV_02_calibration.zip** from Canvas and load all calibration images contained in this archive. Extract and display the checkerboard corners to subpixel accuracy in all images using the OpenCV calibration tools [3 points].



- Determine and output the camera calibration matrix ***K*** using the OpenCV calibration tools [1 point].

```
calibration matrix K:
====================
[[994.93741656   0.         485.13219674]
 [  0.         953.82995312 286.16775088]
 [  0.           0.           1.        ]]
====================
```

- Download the file **Assignment_MV_02_video.mp4** from Canvas and open it for processing. Identify good features to track in the first frame [1 point] using the OpenCV feature extraction and tracking functions. Refine the feature point coordinates to sub-pixel accuracy [1 point].

- Use the OpenCV implementation of the KLT algorithm to track these features across the whole image sequence [1 point]. Make sure to refine the feature point coordinates to sub-pixel accuracy [1 point] in each step.

Task 2-

- Extract and visualise the feature tracks calculated in task 1 which are visible in both
  the first and the last frame to establish correspondences $\boldsymbol{x} \leftrightarrow \boldsymbol{x}'$
  between the two ii
  images [2 points]. Use Euclidean normalised homogeneous vectors.

- Calculate the mean feature coordinates $\boldsymbol{\mu} = {}^{1}\sum_i \boldsymbol{x_i}$ and $\boldsymbol{\mu}' = {}^{1}\sum_i \boldsymbol{x_i}'$ in the first and the last frame [2 points]. Also calculate the corresponding standard deviations
  $\sigma = \sqrt{}^{1}\sum (\boldsymbol{x} - \boldsymbol{\mu})^2$ and $\sigma' = \sqrt{}^{1}\sum (\boldsymbol{x}' - \boldsymbol{\mu}')^2$ (where $(\,)^2$ denotes the

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69
Mean of the first frame: [526.09084599 270.98316773   1.        ]
Mean of the last frame: [536.85093589 246.86237366   1.        ]
Standard Deviation of the first frame:  [154.81588579  67.8869812    0.        ]
Standard Deviation of the last frame: [243.08924062  89.62239282   0.        ]
```

- Select eight feature correspondences at random [1 point] and build a matrix comprising the eight corresponding rows $\boldsymbol{a^T} = \boldsymbol{y^T} \otimes \boldsymbol{y}'$ to calculate the fundamental matrix using the 8-point DLT algorithm [1 point].

- Use the 8-point DLT algorithm to calculate the fundamental matrix $\boldsymbol{F}$ for the eight
  ′
  selected normalised correspondences $\boldsymbol{y_i} \leftrightarrow \boldsymbol{y_i}$ [1 point]**.** Make sure that $\boldsymbol{F}$ is
  ^
  singular [1 point]. Apply the normalisation homographies to $\boldsymbol{F}$ to obtain the
  $'\boldsymbol{T}^{\wedge}$ fundamental matrix $\boldsymbol{F} = \boldsymbol{T}\,\boldsymbol{F}\,\boldsymbol{T}$ [1 point]**.**

- For the remaining feature correspondences $\boldsymbol{x} \leftrightarrow \boldsymbol{x}'$ not used in the 8-point $\boldsymbol{ii}$
  algorithm calculate the value of the model equation [1 point]
  $g = \boldsymbol{x}'^{T}\boldsymbol{F}\boldsymbol{x}_{\,iii}$
  Also calculate the variance of the model equation [1 point]
  $\sigma^2 = \boldsymbol{x}'^{T}\boldsymbol{F}\boldsymbol{C}_{\boldsymbol{x}\boldsymbol{i}\,\boldsymbol{i}\,\boldsymbol{x}\boldsymbol{x}}\boldsymbol{F}^{\boldsymbol{T}}\boldsymbol{x}' + \boldsymbol{x}^{\boldsymbol{T}}\boldsymbol{F}^{\boldsymbol{T}}\boldsymbol{C}_{\boldsymbol{x}\boldsymbol{i}\,\boldsymbol{i}\,\boldsymbol{x}\boldsymbol{x}}\boldsymbol{F}\boldsymbol{x}_{\,i\,i\,xx\,i\,i\,xx\,i}$
  Use the following point observation covariance matrix of the homogeneous features
  100 $\boldsymbol{C_{xx}}$=(0 1 0)

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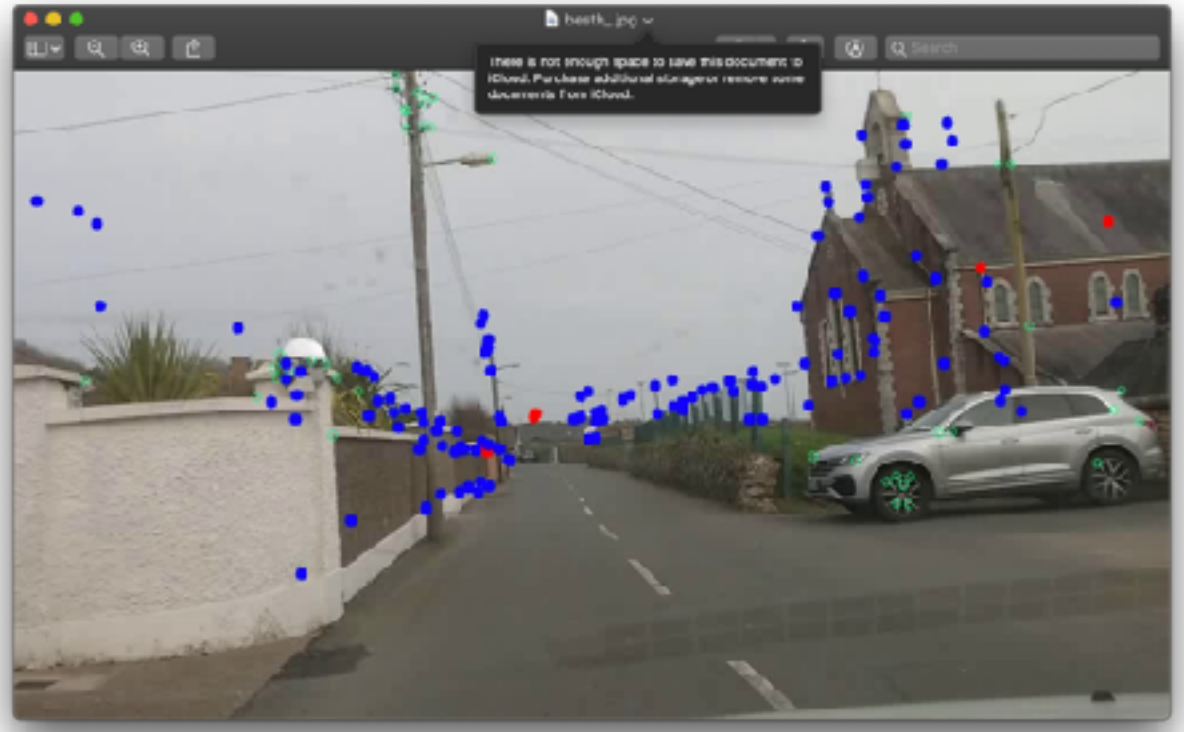
- Determine for each of these correspondences if they are an outlier with respect to the selection of the eight points or not by calculating the test statistic [1 point]



- Adapt the display of feature tracks implemented in subtask A to indicate which of these tracks are inliers and which tracks are outliers [1 point]. Also calculate and output the coordinates of the two epipoles? [2 points]

```
results :
[434.14539754 322.79872856   1.         ]
[432.7902019  320.81340771   1.         ]
```

Part 3:

- Use the fundamental matrix ***F*** determined in task 2 and the calibration matrix ***K*** determined in task 1 to calculate the essential matrix ***E*** [1 point]. Make sure that the non-zero singular values of ***E*** are identical [1 point]. Also make sure that the rotation matrices of the singular value decomposition have positive determinants [1 point].

```
Essential matrix E : [[-5.30986204 33.281171    0.24539434]
 [ 2.03325812 87.54592901  1.63035364]
 [ 2.30006822 -1.79002924  0.11079186]]
```