Guide on
Bird's Eye View Calibration Toolkit

(Implementation of Inverse Perspective Mapping (IPM) technique using Python & OpenCV)

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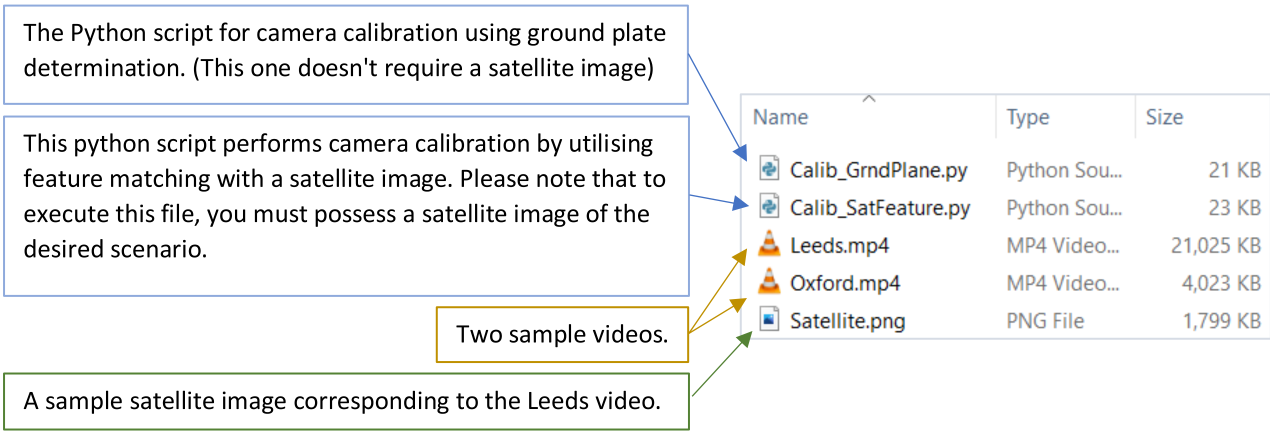
Applied in Publications:

3D-Net: Monocular 3D Object Recognition for Traffic Monitoring
Expert Systems with Applications (2023)
DOI: https://doi.org/10.1016/j.eswa.2023.120253

DeepSOCIAL: Social Distancing Monitoring and Infection Risk Assessment in COVID-19 Pandemic, Applied Sciences (2020)
DOI: https://doi.org/10.3390/app10217514

Included Files

Five files are provided as shown below:



Requirements

- OS: Windows / Linux / Mac
- python 3.8.1 (or above)
- opencv 4.7.0 (or above)
- numpy 1.23.5 (or above)

Calibration using ‘Calib_GrndPlane.py’

This script is useful when a satellite image is not provided with your video file. It allows you to manually determine the ground plane and estimate the BEV calibration points of your camera.

- You can call the script in the OS terminal, like command prompt in windows, using the below command:

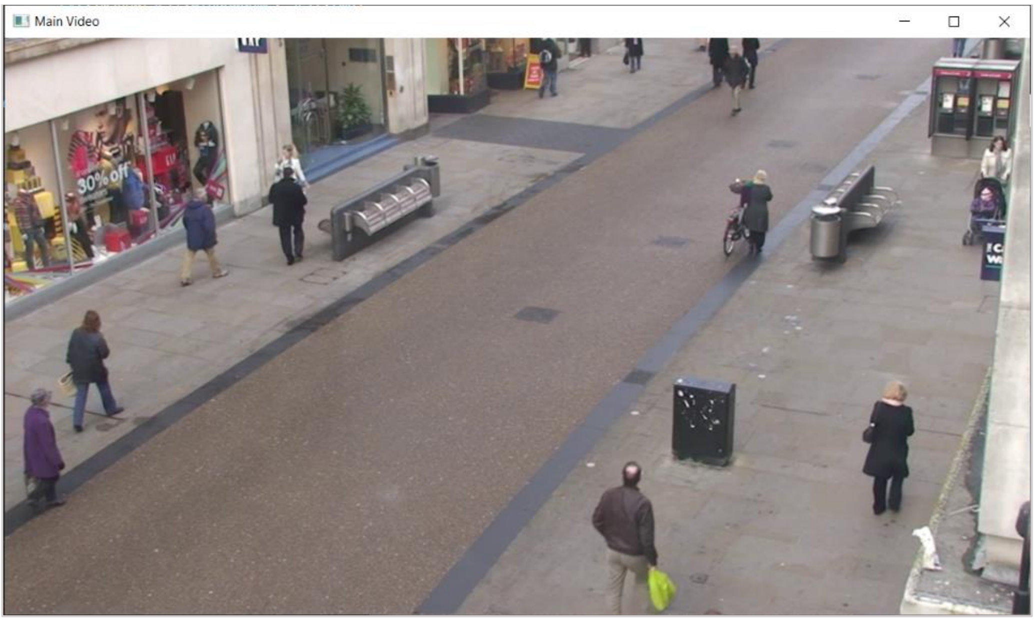
```
python Calib_GrndPlane.py --src Oxford.mp4
```

- You can use your own video path, like:

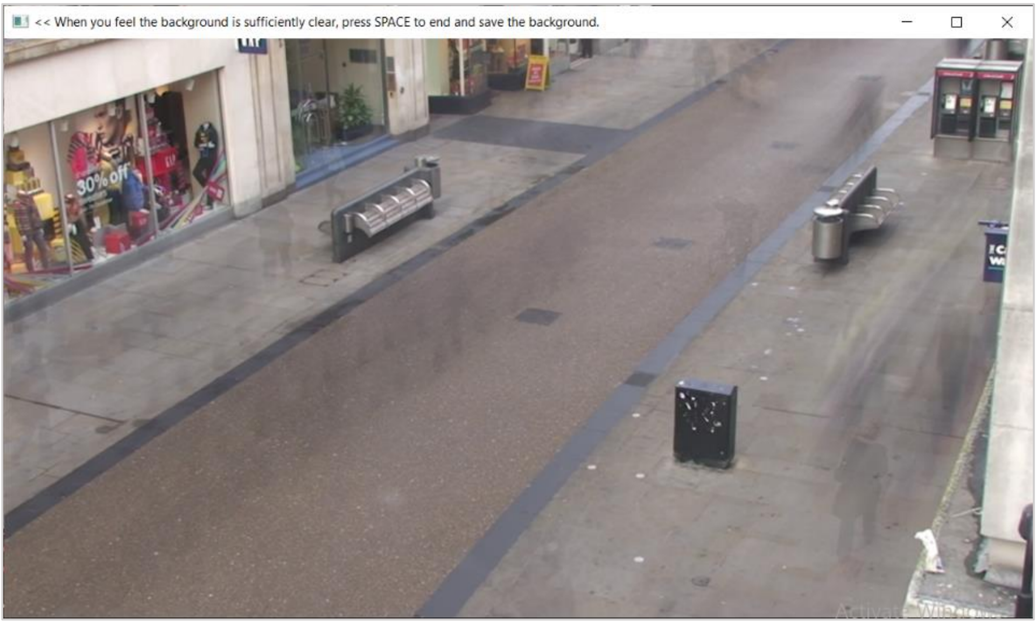
```
python Calib_GrndPlane.py --src C:\My Folder\test.mp4
```

After running the script, it goes through four steps:

1. Extracting the background of the video, which involves removing moving objects in the scene. You will see two windows in this step:



and

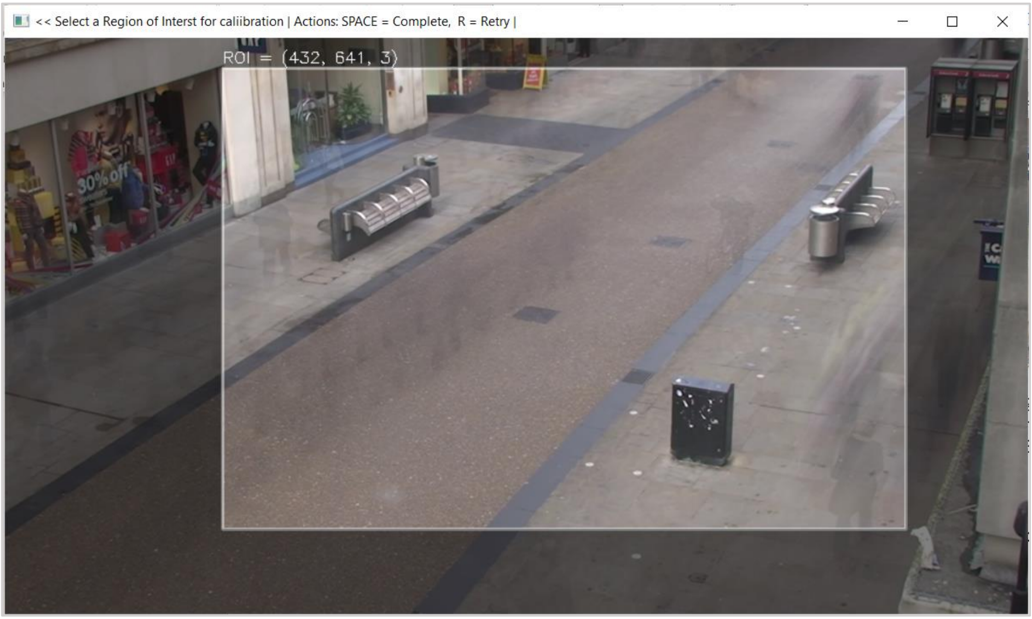


Note: For your own video, you can press the SPACE key to stop the background extraction process when you feel the background is clear.

2. Determining the region of interest (ROI). You can draw a rectangle by dragging the mouse to select the desired part of your scene.

   Note: This step is crucial in preventing the vanishing point from extending to infinity in scenes that include the sky or distant objects.

   This is an example of ROI section:

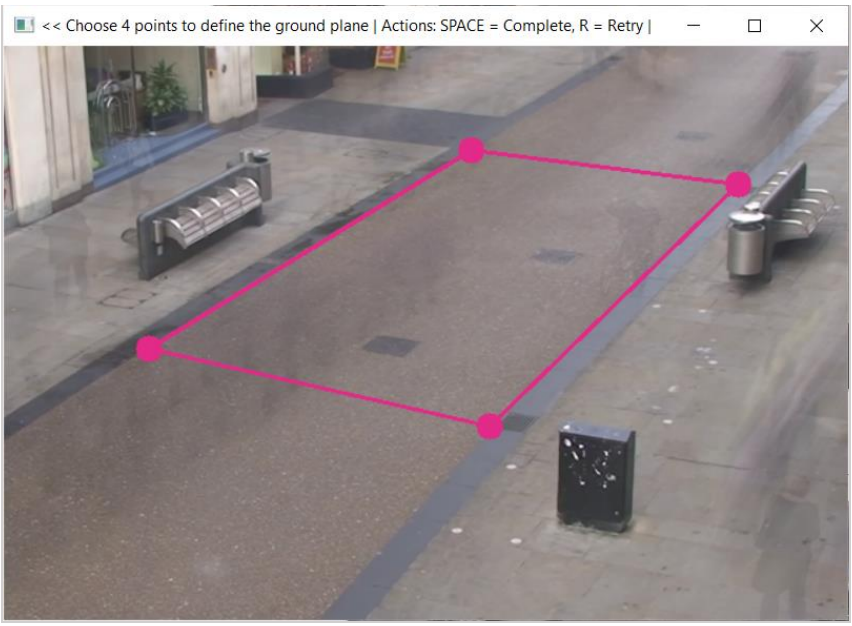


   Note: If you avoid to sect any region and simply press SPACE, the entire scene is considered as your ROI.

   Note: You can use SPACE key on keyboard to confirm, or 'r' to retry the ROI determination.

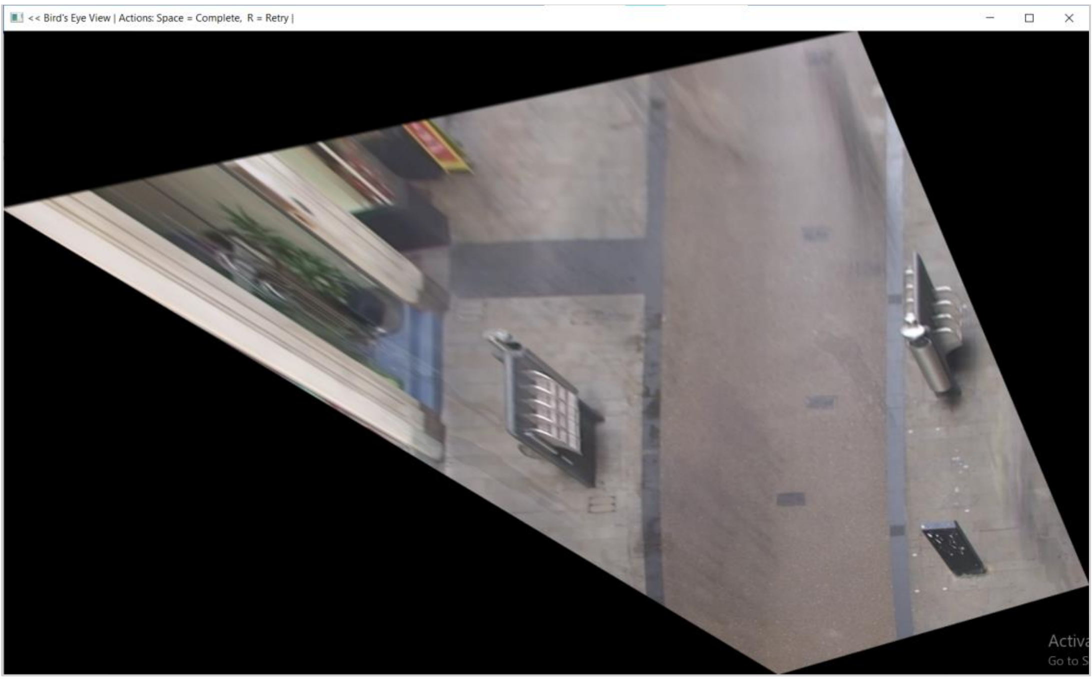
3. Determining the ground plane. Using the mouse, select four points to create a foursquare in the scene to indicate the location of the ground plane.

   Note: The order of points is top-left → top-right → bottom-left → bottom-right.



   Use the SPACE key to confirm the region or the 'r' key to retry. After that, you will see two windows which you can also confirm by pressing SPACE or retry by pressing 'r':

   a) Your ROI in BEV space:



b) The BEV of the foursquare you drawn:

Use the SPACE key to complete the step or the 'r' key to retry.

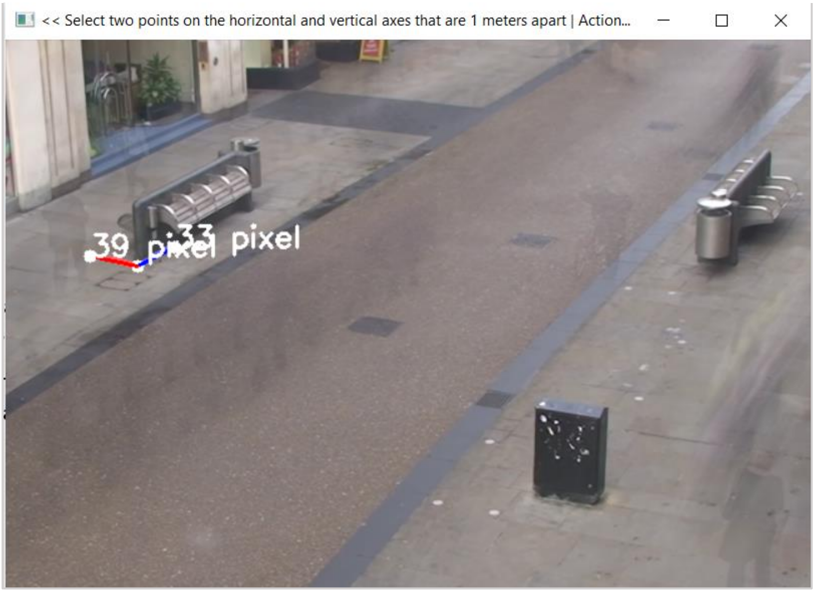
Note: The above image should resemble a satellite photo of the area, but there appears to be some squeezed, especially in the longitudinal direction of the image. For instance, the two tiles in the image appear rectangular, but they are actually square in reality. The inverse perspective transformation of an inaccurate foursquare drawing causes this compression. The next step aims to address this issue.

4. This step aims to refine the aspect ratio of longitude and latitude of the BEV image by determining the pixel-to-meter ratio in two directions. You should determine this ratio by sampling a real measurement of one meter in the perspective scene for two directions. Two orthogonal and identical axes are provided to guide you in determining one meter on longitudinal (blue axis) and latitudinal (red axis) directions.

Note: If the size of these axes doesn't look the same, it means there is squeezing or squishing in the directions.

You can click in an arbitrary location and determine the equivalent of one meter for each directions using guide axes.

In the image above, I have a prior knowledge that the length of the bench is 3 meters, so 1/3 of the bench represents one meter on the vertical axis. The same determination for horizontal axis is measured in the image below:



Use the <u>SPACE</u> key to finish the step or the '<u>r</u>' key to retry.

Finally, the information below is printed in the console:

```
Calibration: Region of Interest: ([204, 31], [846, 468])
Calibration: Coordinate: [[0, 211], [1010, 0], [916, 761], [1284, 655]]
Calibration: BEV size: (761, 1284)
Calibration: Pixel_Unie: (3.834824944236852, 1.9607843137254901)
```

Also, a folder with the same name as the video file in the same path is made containing the configuration file, config.txt, and the photos represents each step you have taken.

Calibration using ‘Calib_SatFeature.py’

In order to use this script to estimate the BEV coordinates, you must provide a satellite image of the location where your video is recorded. This image is intended to serve as the ground plane indicator, so if there is a steep incline or slope, it is better to use the manual calibrator provided.

- You can call the script in the OS terminal, like command prompt in windows, using the below command:

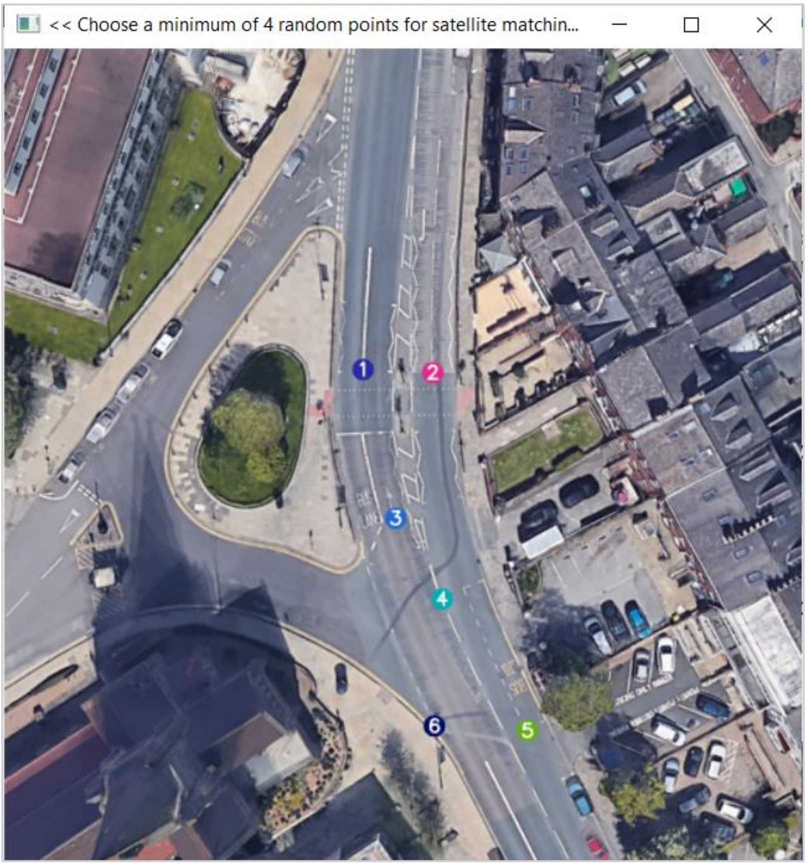
```
python Calib_SatFeature.py --src Leeds.mp4 --sat Satellite.png
```

- You can use your own video path and the corresponding satellite image, like:

```
python Calib_SatFeature.py --src C:\test.avi –sat C:\Satellite_of_test.jpg
```

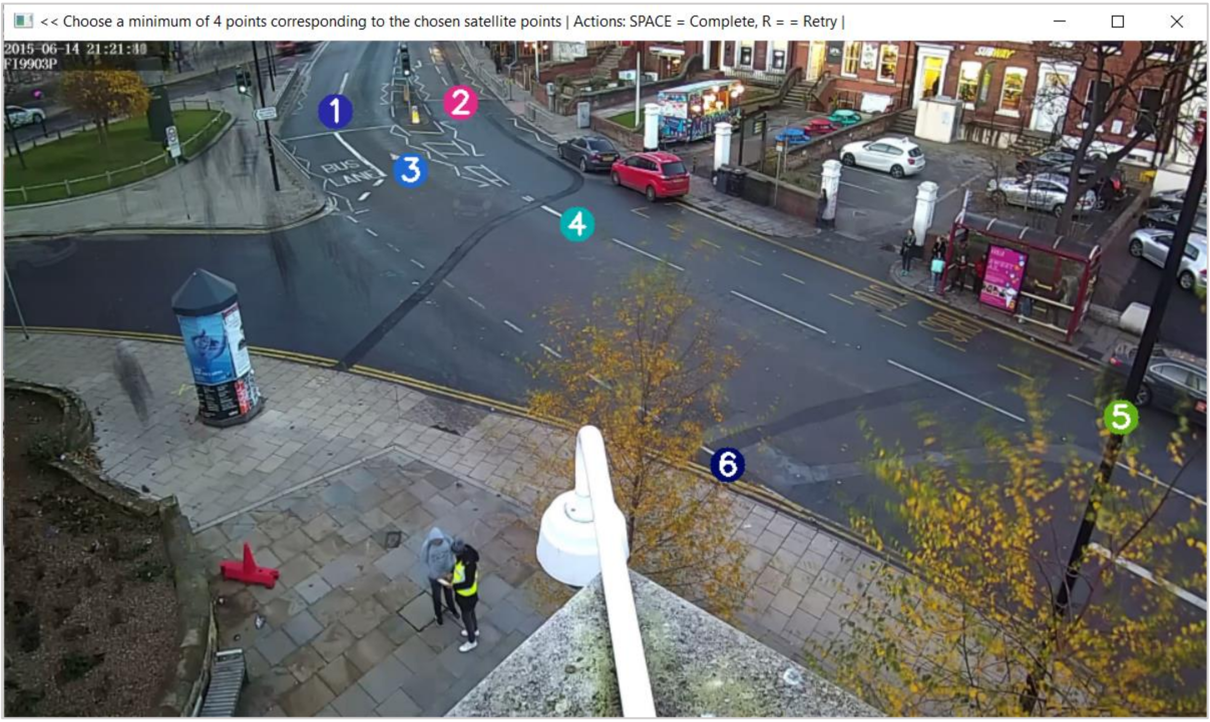
The calibration process is similar to manual calibration, except for step 3, where you need to identify at least four points in the satellite image that correspond to points in the video scene.

Initially, this will involve identifying at least four points in the satellite image that you can confidently reidentify in the video scene image. For instance, in the image below, 6 points have been identified.



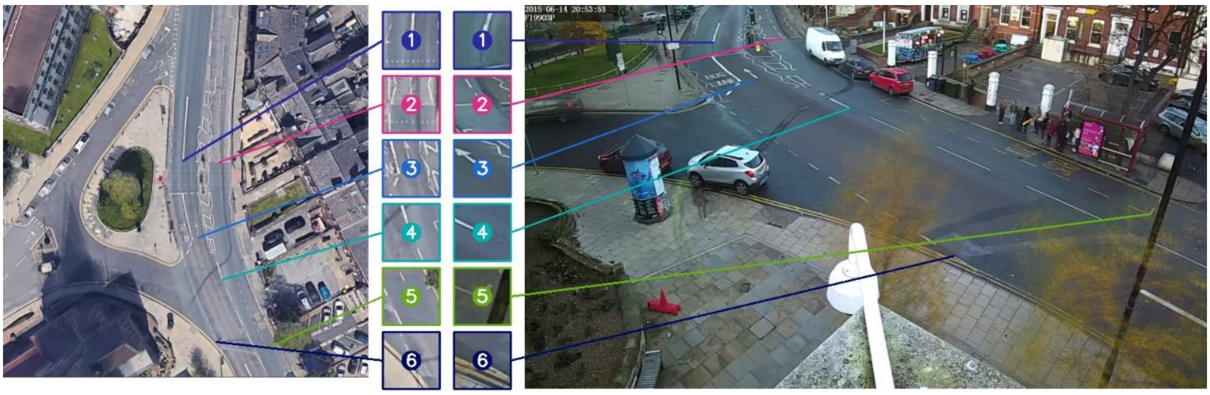
Use the SPACE key to confirm the chosen points or the 'r' key to retry.

Next, you will reidentify the selected points in the video scene image. The image below shows an example of the corresponding 6 points chosen in the satellite image.



Use the SPACE key to confirm the chosen points or the 'r' key to retry.

The window below shows a summary of the matched pairs in both satellite and video scenes. Press the SPACE key to confirm the pairs or the 'r' key to reselect.



Note: Some items in this window may appear in the incorrect order. This is a bug in the representation of the window, but it does not affect the calibration process.

Afterwards, the overlap map will visually demonstrate the calibration results. The satellite image serves as the background, while the video scene image is shown in the foreground. The transformation process has been applied to overlay the selected points in these images.

You can use the SPACE key to confirm the calibration or the 'r' key to retry.

Note: This calibration is determined by a vote among selected points. Therefore, it is advisable to consider diversity in terms of point location. The accuracy of the calibration is highly dependent on the location of the points selected. If you find the results to be inaccurate, please repeat the process or reconsider the matching points.

Ultimately, the calibration information is displayed in the console. Additionally, a folder with the identical name as the video file is created in the same path, which contains the configuration file, config.txt, and photos representing each step taken.

The End.