IMA208 - Stereo Vision

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As instructed during class, this report covers parts 1 through 3 of the practical work.

1. Calcul des images en géométrie épipolaire

1.1. Sélection de la zone traitée

The selected points on *amiens1.tif* are: x1=2336, y1=2453, x2=4005, y2=3984. The corresponding points on *amiens2.tif* are: x1=1968, y1=1242, x2=3728, y2=2752.

1.2. Calcul des matrices de rotation 3D pour le passage de la géométrie originale à la géométrie épipolaire

The application of the script produced the following results:

```
tp-1a201-04% rotation.sh amiens1 amiens2                                ~/tp-stereo
base : 295840.000000 100674.000000 809.000000
  -0.9466833258    0.3221562889   -0.0024507699
  -0.3221552094   -0.9466864980   -0.0008339941
  -0.0025887872    0.0000000000    0.9999966491
Delta y in epipolar plane - two step projection: 0.00000 mm
Delta y in epipolar plane - one step projection: 0.00000 mm
Cross comparaison, left : -0.00000, right : 0.00000
New base components (-312501.543, -0.000, 0.000)
```

Question 1 : rappelez quelle propriété doit vérifier le plan dans lequel les deux images sont ré échantillonnées.

In the plane in which the images will be resampled the epipolar lines must be parallel to each other. Furthermore, corresponding points must have the same y coordinate value.

Question 2 : à quelle transformation géométrique 2D est équivalente cette rotation du plan image autour du centre optique ?

The rotation of the image plane around the optical center is equivalent to a homography.

1.3. Calcul des coordonnées caméra en géométrie épipolaire

The application of the script produced the following results:

```
tp-1a201-04% image2epipolaire.sh amiens1 2336 2453 4005 3984                    ~/tp-stereo
(     3.829,     2.763)
 (    19.761,    16.202)
 (     5.805,    17.883)
 (    17.656,     1.019)
 x_start     3.83 y_start   17.88
x_size     1770 y_size     1873
```

```
tp-1a201-04% image2epipolaire.sh amiens2 1968 1242 3728 2752                    ~/tp-stereo
(    -7.366,     1.989)
 (     8.264,    16.266)
 (    -5.467,    18.021)
 (     6.143,     0.285)
 x_start    -7.37 y_start   18.02
x_size     1736 y_size     1970
```

1.4. Rééchantillonnage en géométrie épipolaire de la zone sélectionnées dans les deux images aériennes

The application of the script produced the following results:

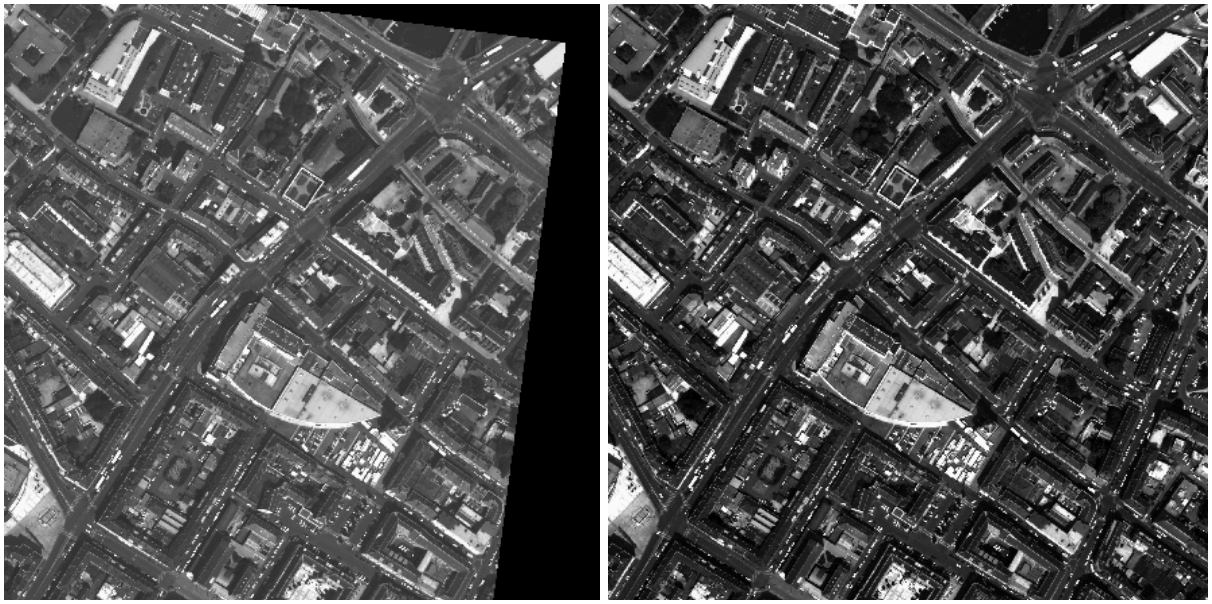
```
tp-1a201-04% reechantillonnage.sh amiens1 amiensG 3.83 17.88 2000 2000          ~/tp-stereo
Lecture de l'image TIFF <./amiens1.tif>
LargeurxHauteur : 4096x4096

nom du fichier : amiensG.tif
Taille du pixel : 0.009000
transforming the image... : 2000 2000
0 64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024 1088 1152 1216 1280 1344 140
8 1472 1536 1600 1664 1728 1792 1856 1920 1984
OK
nombre de frames : 1
nombre de plans image : 1
```

```
tp-1a201-04% reechantillonnage.sh amiens2 amiensD -7.37 17.88 2000 2000         ~/tp-stereo
Lecture de l'image TIFF <./amiens2.tif>
LargeurxHauteur : 4096x4096

nom du fichier : amiensD.tif
Taille du pixel : 0.009000
transforming the image... : 2000 2000
0 64 128 192 256 320 384 448 512 576 640 704 768 832 896 960 1024 1088 1152 1216 1280 1344 140
8 1472 1536 1600 1664 1728 1792 1856 1920 1984
OK
nombre de frames : 1
nombre de plans image : 1
```

Below, on the left is the image *amiensG.tif* and on the right *amiensD.tif*.



Question 3 : pourquoi doit-on choisir la même ordonnée <y start> pour le rééchantillonnage des deux images en géométrie épipolaire ?

We must choose the same starting y coordinate when resampling the two images on epipolar geometry so that corresponding points have the same y coordinate on both images; that way the search for corresponding points is reduced to a 1D search where we only have to search for the point on image 2 on the same line of the point of image 1.

1.5. Vérification de la géométrie épipolaire, et sélection de l'intervalle de disparité

Question 4 : comment cet intervalle de disparité pourrait-il être calculé à partir des données de prise de vue ?

The disparity interval could be computed if we had *a priori* information about the scene and knew the height of the lowest and of the highest point on the scene, we could thus compute the minimal and maximal disparity and limit the search interval.

2. Calcul de l'image de disparité

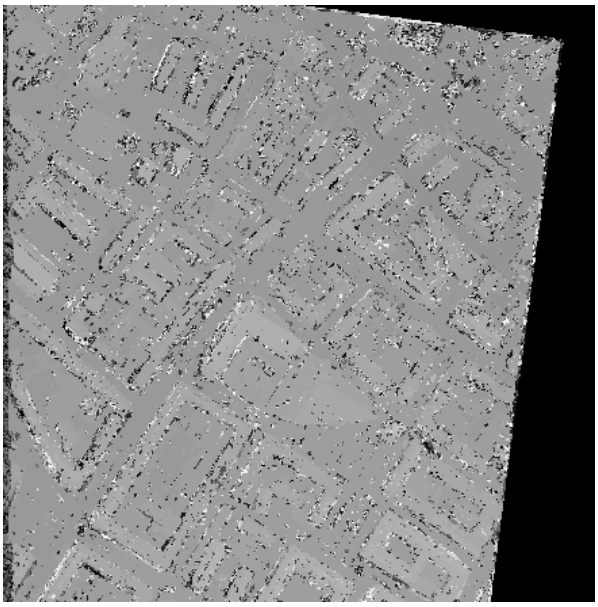
2.1. Corrélation croisée centrée normalisée

Question 5 : quelle information fournit l'image correl.tif ?

The image *correl.tif* gives the correlation value between the target window and the best match window. The image below is the correlation map obtained for a window of radius 5.

Question 6 : quelle information fournie l'image dispa.tif ?

The image *dispa.tif* gives the disparity map. The image below is the disparity map obtained for a window of radius 5.

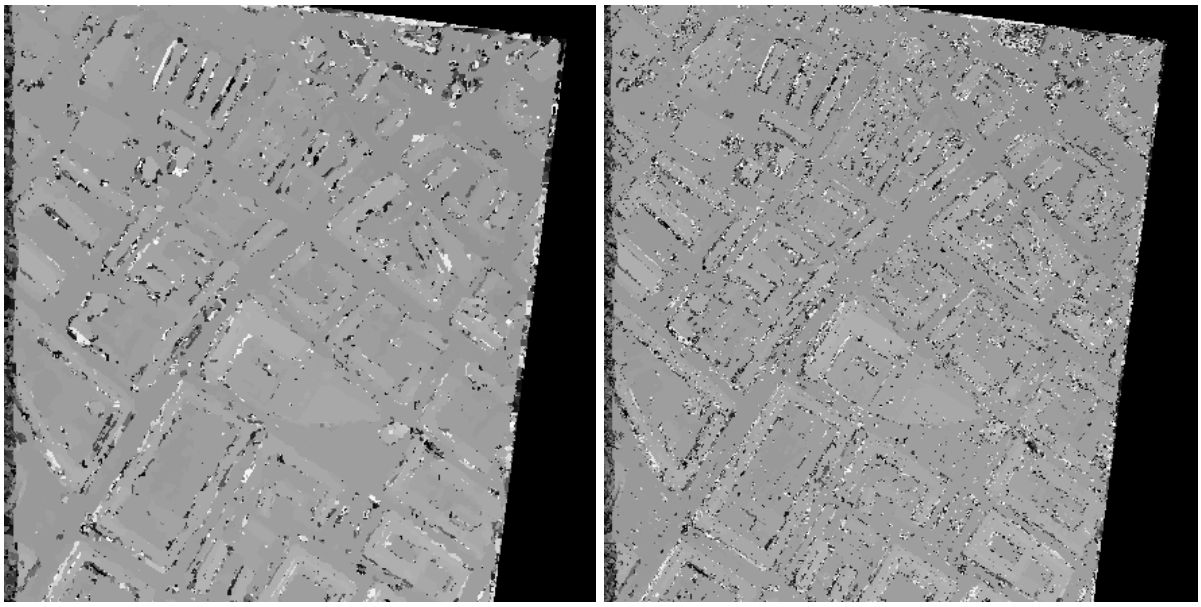


Question 7 : quelles sont les conséquences d'un intervalle de disparité mal choisi (trop petit ou trop grand) ?

The consequence of choosing a disparity interval that is too small is that we won't be able to find the corresponding points on the right image. On the other hand, choosing an interval that is too big will add an unnecessary cost to the search, also there will be a higher probability of returning false matches.

Question 8 : comment évolue la carte de disparité dispa.tif si l'on fait varier le rayon de la fenêtre de corrélation ?

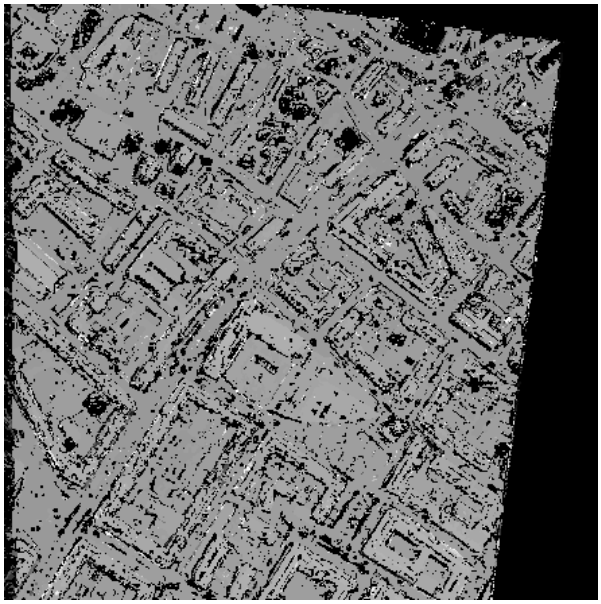
By making the correlation window smaller, we obtain a more precise disparity map, however it is less robust and more sensitive to noise. By choosing a larger window, the disparity map will be more robust but less accurate. This can be seen on the images below: on the left we have a disparity map for a correlation window of radius 10 and on the right of radius 5.



2.2. Seuillage sur le coefficient de corrélation

Question 9 : quel compromis êtes-vous obligés de faire en choisissant ce seuil ?

When choosing a threshold on the correlation value below which the match is discarded, there is a trade-off between accepting wrong matches and losing good matches. If the threshold is too small we might be accepting false matches that corrupt the disparity map, on the other hand, if the threshold is too high we will be discarding matches that were in fact good and so we get a disparity map with missing information, as represented in the image below where a threshold of 0.8 was used.

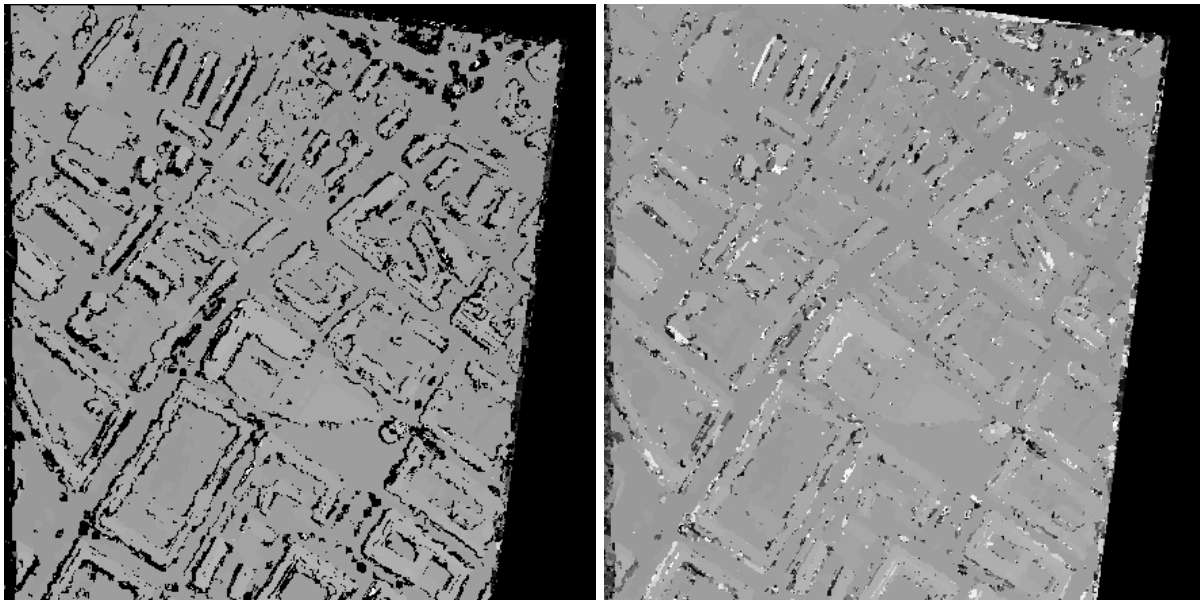


2.3. Corrélation aller-retour

Question 10 : expliquez le principe de cette méthode, et dites pourquoi elle peut permettre de rendre compte des parties cachées.

The standard “one-way” algorithm for computing the disparity map using correlation privileges image 1 in the sense that for each point of this image the best match on image 2 is computed, but there is no guarantee that for this point of image 2, there is not a point of image 1 that matches it better. In the “two-way” correlation method, we consider that points are in correspondence only if they "choose" each other, which is better adapted to cases where there are hidden areas. On the “one-way” algorithm we may find a weakly correlated wrong match B for a point A on image 1 that is actually hidden on image 2; however if we use the “two-way” algorithm, there will be a point C on image 1 that matches point B of image 2 better, so A and B will not “choose” each other, and the wrong match will be discarded.

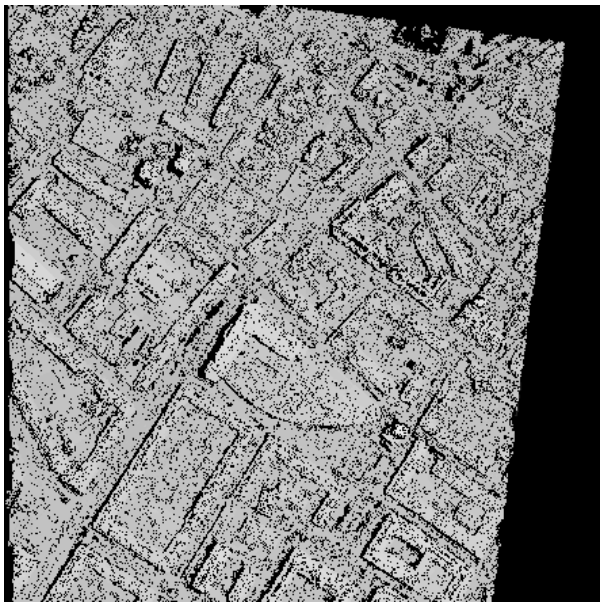
Below we can see, on the left, the disparity map generated by the “two-way” algorithm and, on the right, the disparity map generated by the “one-way” algorithm, both for a correlation window of radius 10. We see that in the “two-way” algorithm the disparity map doesn’t have any information about the borders of the buildings, which are areas that are hidden on one of the two *amiens* images.



2.4. Approche hiérarchique avec relaxation

Question 11 : pouvez-vous indiquer pour quels types de zone de la scène traitée cette méthode ne fournit pas d'information : points à 0 de la carte de disparité dispa-amiens.tif ?

We see that the method does not give information about the hidden parts of the image, that is, the areas just around the borders of the buildings, as can be seen in the image resulting from the script:



3. Visualisation du nuage de points 3D

The 3D point cloud obtained for the disparity map of section 2.4 is shown below.