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ECE

MOBILE ROBOTICS

(CAMERA CALIBERATION ASSIGNMENT)

REPORT

- Read all the five images using, the function "detectCheckerboardPoints() " and commands like "imread()";
- This will read and put the detected points in array of size (48*2) for every image in imagepoints array in the code.
- Next generate the "World co-ordinates" using generateCheckerboardPoints(boardSize, squareSize); command.
  We get a (48*2) array of world points.
- We take corners of board for every image and then, take world points and image points corresponding to those corners as X(),Y(), and x(),y() 's respectively.
- As a part of Zhang's method ,construct matrix "M"(here a for each image,from the definition given for Mp=0) , perform SVD of it to obtain "h"(Homographies h1,h2,h3).
- Later, construct matrix "V"(6*1)(using linear combinations of elements of 'h' matrix from it's definition).
- Perform it's SVD and get matrix "B".Later apply Chol() on it to get inverse(K).
- Finally we obtain the camera calibration matrix "K".
- Obtaining R,t from "K":
  - Multiply inv(K) and H for each image to get 'R' corresponding to each rotation and 't'.(last column in obtained matrix after multiplication=t)
  - The third column of rotation matrix(R) can be found by taking sum of norms of columns 1,2.

The results obtained for selected 4 points i.e corners of the checker board in world co-ordinates and image co-ordinates are as follows,

```
hhhhhhhhhhh
   -0.0010     0.0024     0.7770
   -0.0023    -0.0013     0.6294
    0.0000    -0.0000     0.0020


hhhhhhhhhhh
    0.0021    -0.0001     0.4805
   -0.0018     0.0013     0.8770
   -0.0000    -0.0000     0.0029


hhhhhhhhhhh
    0.0006     0.0030     0.6252
   -0.0029    -0.0012     0.7805
    0.0000    -0.0000     0.0020
```

This gives the "H" matrices corresponding to 3 images used.(1,2,3)

```
The matrix "V" to be solved
   1.0e-04 *

   -0.0239    -0.0414     0.0000     0.0285    -0.0000    -0.0000
   -0.0458     0.1053    -0.0000     0.0364    -0.0000     0.0000
   -0.0031     0.0303    -0.0001    -0.0233     0.0000     0.0000
    0.0449    -0.0723    -0.0001     0.0152     0.0001    -0.0000
    0.0170    -0.0952     0.0001     0.0361     0.0000    -0.0000
   -0.0897     0.0436     0.0001     0.0684    -0.0002     0.0000

The matrix B on which chol is to be applied
    0.0000     0.0000    -0.0005
    0.0000     0.0000    -0.0005
   -0.0005    -0.0005     1.0000
```

These are intermediate matrices constructed "V" and "B"(matrix to solve for K).

```
The K matrix
   656.2762   -30.9053   256.4099
         0    684.0761   229.1861
         0           0     1.1303

Rotation matrices  R1,2|t
   -0.0000     0.0000     0.0005
   -0.0000    -0.0000     0.0003
    0.0000    -0.0000     0.0017

    0.0000     0.0000    -0.0002
   -0.0000     0.0000     0.0004
   -0.0000    -0.0000     0.0025

   -0.0000     0.0000     0.0003
   -0.0000    -0.0000     0.0006
    0.0000    -0.0000     0.0018
```

The obtained matrices "K" (camera calibration matrix), matrices corresponding to 3 images
with first 2 columns of rotation matrix and their last column being 't'.

For different set of points taken, (other than corners of checker board),we get,
(Set #2)

(1,5,43,48)

```
hhhhhhhhhhhh
   -0.0010    0.0023    0.7770
   -0.0023   -0.0012    0.6294
    0.0000   -0.0000    0.0020

hhhhhhhhhhhh
   -0.0022    0.0001   -0.4805
    0.0018   -0.0013   -0.8770
    0.0000    0.0000   -0.0029

hhhhhhhhhhhh
    0.0005    0.0030    0.6252
   -0.0029   -0.0012    0.7805
    0.0000   -0.0000    0.0020

The matrix "V" to be solved
   1.0e-04 *

   -0.0242   -0.0410    0.0000    0.0285   -0.0000   -0.0000
   -0.0445    0.1057   -0.0000    0.0370   -0.0000    0.0000
   -0.0024    0.0310   -0.0001   -0.0238    0.0000    0.0000
    0.0466   -0.0734   -0.0001    0.0131    0.0001   -0.0000
    0.0163   -0.0941    0.0001    0.0361    0.0000   -0.0000
   -0.0876    0.0434    0.0001    0.0688   -0.0002    0.0000
```

```
The matrix B on which chol is to be applied
    0.0000    0.0000   -0.0005
    0.0000    0.0000   -0.0004
   -0.0005   -0.0004    1.0000

The K matrix
  675.7081  -25.8725   255.8372
        0   696.6559   209.6098
        0         0     1.1148

Rotation matrices   R1,2|t
   -0.0000    0.0000    0.0005
   -0.0000   -0.0000    0.0004
    0.0000   -0.0000    0.0018

   -0.0000   -0.0000    0.0002
    0.0000   -0.0000   -0.0005
    0.0000    0.0000   -0.0026

   -0.0000    0.0000    0.0003
   -0.0000   -0.0000    0.0006
    0.0000   -0.0000    0.0018
```

Set #3 (1,5,46,48)

```
nnnnnnnnnnnnnn
   -0.0010     0.0024     0.7770
   -0.0023    -0.0012     0.6294
    0.0000     0.0000     0.0020


hhhhhhhhhhhh
    0.0020    -0.0001     0.4805
   -0.0019     0.0013     0.8770
   -0.0000    -0.0000     0.0029


hhhhhhhhhhhh
    0.0004     0.0032     0.6252
   -0.0030    -0.0011     0.7805
    0.0000    -0.0000     0.0020


The matrix "V" to be solved
   1.0e-04 *

   -0.0251    -0.0442     0.0000     0.0277    -0.0000     0.0000
   -0.0490     0.1060    -0.0000     0.0393    -0.0000     0.0000
   -0.0025     0.0291    -0.0001    -0.0246     0.0000     0.0000
    0.0412    -0.0728    -0.0001     0.0177     0.0001    -0.0000
    0.0127    -0.1013     0.0001     0.0329     0.0000    -0.0000
   -0.1021     0.0466     0.0001     0.0788    -0.0002     0.0000

The matrix B on which chol is to be applied
    0.0000     0.0000    -0.0008
    0.0000     0.0000    -0.0007
   -0.0008    -0.0007     1.0000


The K matrix
  609.2821   -17.4664   355.2613
        0   636.2633   365.3505
        0          0     1.2997


Rotation matrices  R1,2|t
   -0.0000     0.0000     0.0004
   -0.0000    -0.0000     0.0001
    0.0000     0.0000     0.0015


    0.0000     0.0000    -0.0005
   -0.0000     0.0000     0.0001
   -0.0000    -0.0000     0.0022


   -0.0000     0.0000     0.0001
   -0.0000    -0.0000     0.0003
    0.0000    -0.0000     0.0015
```