EXTRACCIÓN CARACTERÍSTICAS

Módulo features2D (e7.py)

- Puntos Característicos: SIFT/SURF/ORB
- Descriptores: SIFT/SURF/ORB

https://docs.opencv.org/4.5.5/d5/d51/group__features2d__main.html
https://docs.opencv.org/4.5.5/d3/df6/namespacecv_1_1xfeatures2d.html

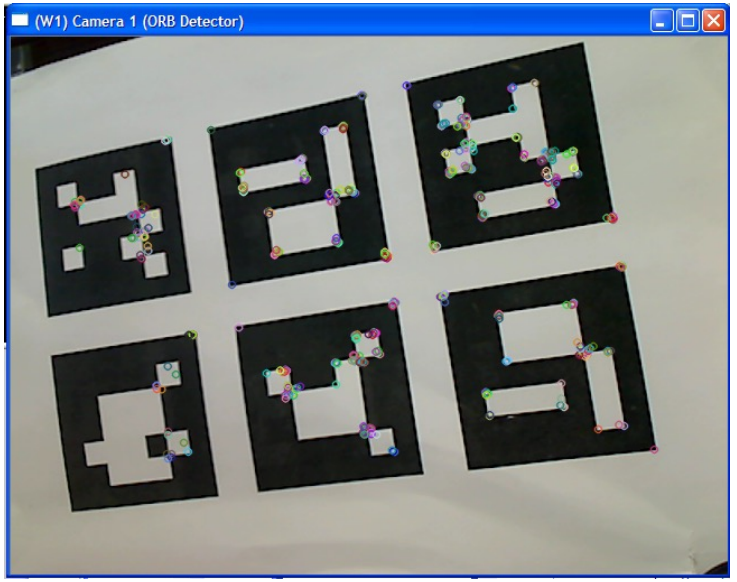
https://docs.opencv.org/4.5.5/db/d27/tutorial_py_table_of_contents_feature2d.html

Extracción Características: módulo features2D

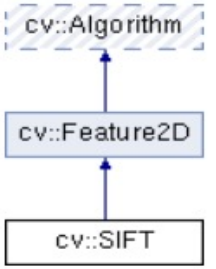
- Ejemplo (**e7.py**): partiremos del código **e1.py**
- Detectores:
  - Lista de puntos: tuplas/listas de objetos cv.**KeyPoint**
    - **pt**: tuple (x,y), **size**: float, **angle**: float, **response**: float, **octave**:int, **class_id**:int
    - cv.**KeyPoint**( ) → <KeyPoint object>
    - cv.**KeyPoint**(**x**, **y**, **size**[, **angle**[, **response**[, **octave**[, **class_id**]]]]) → <KeyPoint object>
  - **SIFT**, **ORB**, **AKAZE**, **KAZE**, **FAST, MSER**, **GFTT** [, **HARRIS**], **AGAST**, **BRISK**, **SimpleBlob**
  - **SURF**, **STAR, MSD, TBMR, HARRISLP** **(modulo xfeatures2D – opencv-contrib)**
- Descriptores: Vectores de características (por filas): **ndarray(np,nc)**
  - **SIFT, ORB**, **AKAZE(MLDB), KAZE(MSURF), BRISK**

  (modulo xfeatures2D)
  - **SURF**, **FREAK**, **VGG, BRIEF, DAISY**
    LUCID, LATCH, BOOST, BEBLID

```
Capturing images.
 Hit q/Q to exit.
Detected: 500 points
Descriptor Dimension: 32
[168, 114, 58, 109, 96, 14, 115, 120, 121, 10, 118, 88, 95, 27, 11, 48, 180, 17,
 70, 106, 224, 180, 49, 15, 231, 217, 32, 1, 66, 128, 106, 163]_
```



Extracción Características: módulo features2D



- Ejemplo (**e7.py**): extracción de características
- Clase: **SIFT**: cv.**SIFT**
  - cv.**SIFT_create**([, **nfeatures**=0 [, nOctaveLayers=3 [, contrastThreshold=0.04 [, edgeThreshold=10 [, sigma=1.6]]]]]) → detector (cv.SIFT)

- Clase base: cv.**Feature2D**

  Detectar Puntos:
  - cv.Feature2D.**detect**(**image** [, **mask**]) → keypoints (tupla de cv.KeyPoint)
  - cv.Feature2D.**detect**(**images** [, **masks**]) → keypoints
    - mask: 8-bit binary matrix with non-zero values in the region of interest

  Calcular Descriptores:
  - cv.Feature2D.**compute**(**image**, **keypoints**[, **descriptors**]) → keypoints, descriptors
  - cv.Feature2D.**compute**(**images**, **keypoints**[, **descriptors**]) → keypoints, descriptors

    Si no existe el descriptor para un punto se elimina el keypoint.
    También se pueden añadir nuevos (múltiples orientaciones dominantes)

    descriptors: ndarray(np,ds)

  - cv.Feature2D.**detectAndCompute**(**image**, **mask**[, **descriptors**[, **useProvidedKeypoints**=False]]) → keypoints, descriptors
  - cv.Feature2D.**descriptorSize**() → retval
  - cv.Feature2D.**descriptorType**() → retval

Extracción Características: módulo features2D

- Ejemplo (**e7.py**): **SIFT** partiremos del código **e1.py**

```
FEATURE_TYPE = 'SIFT'              # Default Feature Detector sift/surf/orb

# check command line parameters
parser = argparse.ArgumentParser(description='OpenCV example: Feature Points Detector')
parser.add_argument( '-c',  dest='cameraID',  type=int, default=CAMERA_ID, metavar='id',  help='camera id')
parser.add_argument( '-f', dest='feature', type=str, default=FEATURE_TYPE, metavar='feature',
                                                    help='sift | surf | orb')
CAMERA_ID = parser.parse_args().cameraID
FEATURE_TYPE = parser.parse_args().feature.lower()          # feature (lowercase)
```

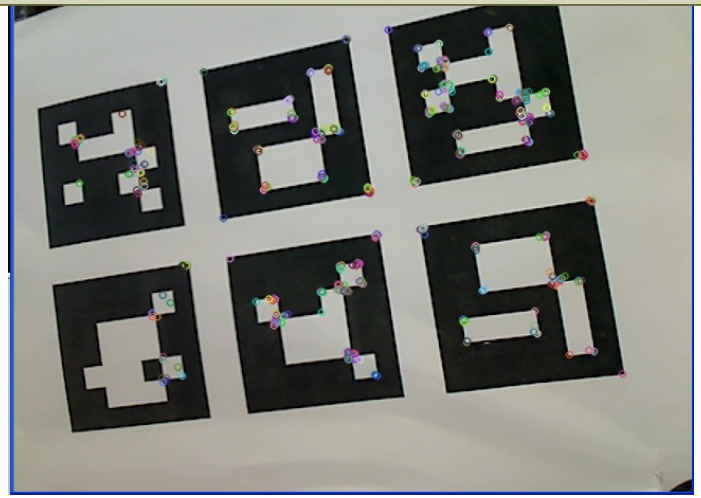
```
# Initialization section
if FEATURE_TYPE == 'sift':
        detector = cv.SIFT_create(100)

# Detector information
print(f"{FEATURE_TYPE=}")
print(f"{detector.descriptorSize()=}")
```

```
# processing section (image capture loop)
gray_image = cv.cvtColor(capture, cv.COLOR_BGR2GRAY)

keypoints = detector.detect(gray_image)
keypoints, descriptors = detector.compute(gray_image, keypoints)
```

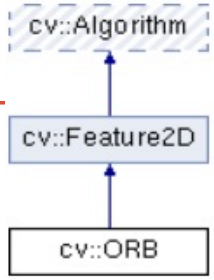
Extracción Características: módulo features2D

- Ejemplo (**e7.py**): Dibujar puntos
  - cv.**drawKeypoints**(**image**, **keypoints**, **outImage**[, **color=**-1 [, **flags**]]) → outImage
    - **outImage:** *None* (DEFAULT flags), Imagen de fondo (DRAW_OVER_OUTIMG)
    - **color**: tupla, (-1 random)
    - **flags**: cv.DRAW_MATCHES_FLAGS_DEFAULT, (crea *outimage* con *image* como fondo)
      cv.DRAW_MATCHES_FLAGS_DRAW_OVER_OUTIMG,
      cv.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS,
      cv.DRAW_MATCHES_FLAGS_NOT_DRAW_SINGLE_POINTS

```
# Draw keyPoints
dispimage  = cv.drawKeypoints( capture, keypoints, outImage=None,
                               flags=cv.DRAW_MATCHES_FLAGS_DRAW_RICH_KEYPOINTS )

cv.imshow(WINDOW_CAMERA1, dispimage)     # Display the resulting frame
```



Extracción Características: módulo features2D

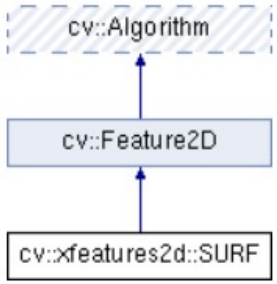


- Ejemplo (**e7.py**): extracción de características
- Clase: **ORB**: cv.**ORB**
  - cv.**ORB_create**([, **nfeatures**=500 [, scaleFactor=1.2 [, nlevels=8 [, edgeThreshold=31 [, firstLevel=0 [, WTA_K=2[, scoreType=cv.ORB_HARRIS_SCORE [, patchSize=31 [, fastThreshold=20]]]]]]]]) → detector (cv.ORB)
- Métodos:
  - cv.ORB.**setMaxFeatures**(maxFeatures)

```
# Initialization section
elif FEATURE_TYPE == 'orb':
      detector = cv.ORB_create(nfeatures=100)
```

```
# processing section (image capture loop)
gray_image = cv.cvtColor(capture, cv.COLOR_BGR2GRAY)

keypoints = detector.detect(gray_image)
keypoints, descriptors = detector.compute(gray_image, keypoints)
```

Extracción Características: módulo features2D



- Ejemplo (**e7.py**): extracción de características
- Clase: **SURF**: cv.**xfeatures2d_SURF**

  (modulo xfeatures2D – opencv-contrib) (patentado)

  SURF: Precisa compilacion con **OPENCV_ENABLE_NONFREE flag**

  - cv.xfeatures2d.**SURF_create**([, **hessianThreshold**=100 [, nOctaves=4 [, nOctaveLayers=3 [, extended=False [, upright=False]]]]]) → detector (cv. xfeatures2D_SURF)
- Métodos:
  - cv.xfeatures2d_SURF.**setExtended**(extended) Tamaño descriptor → True: 128, **False**: 64
  - cv.xfeatures2d_SURF.**setHessianThreshold**(hessianThreshold)

```
# Initialization section
elif FEATURE_TYPE == 'surf':
      detector = cv.xfeatures2d.SURF_create(hessianThreshold=400)
```

```
# processing section (image capture loop)
gray_image = cv.cvtColor(capture, cv.COLOR_BGR2GRAY)

keypoints = detector.detect(gray_image)
keypoints, descriptors = detector.compute(gray_image, keypoints)
```

Extracción Características: módulo features2D

- Resumen Detectores y Descriptores
- Detectores:
  - cv.**SIFT_create**()
  - cv.**ORB_create**()
  - cv.**AKAZE_create**()
  - cv.**KAZE_create**()
  - cv.**BRISK_create**()
  - cv.**FastFeatureDetector_create**()
  - cv.**MSER_create**()
  - cv.**GFTTDetector_create**()
  - cv.**AgastFeatureDetector_create**()
  - cv.**SimpleBlobDetector_create**()
- Paquete opencv-contrib-python:
  - cv.xfeatures2d.**SURF_create**()
  - cv.xfeatures2d.**StarDetector_create**()
  - cv.xfeatures2d.**MSDDetector**()
  - cv.xfeatures2d.**TBMR_create**()
- Descriptores:
  - cv.**SIFT_create**()
  - cv.**ORB_create**()
  - cv.**AKAZE_create**()
  - cv.**KAZE_create**()
  - cv.**BRISK_create**()
- Paquete opencv-contrib-python:
  - cv.xfeatures2d.**SURF_create**()
  - cv.xfeatures2d.**BEBLID_create**()
  - cv.xfeatures2d.**BoostDesc_create**()
  - cv.xfeatures2d.**DAISY_create**()
  - cv.xfeatures2d.**FREAK_create**()
  - cv.xfeatures2d.**LATCH_create**()
  - cv.xfeatures2d.**LUCID_create**()
  - cv.xfeatures2d.**VGG_create**()

CORRESPONDENCIA CARACTERÍSTICAS

Módulo features2D (e7b.py)

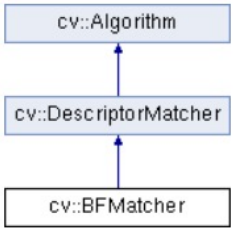
DescriptorMatcher

https://docs.opencv.org/4.5.5/d8/d9b/group__features2d__match.html

https://docs.opencv.org/4.5.5/dc/dc3/tutorial_py_matcher.html

Correspondencia Características: módulo features2D

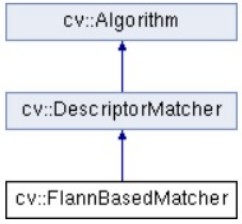
- Ejemplo (**e7b.py**): extracción de características /matching
- Matchers: cv.**BFMatcher** (Brute Force) / cv.**FlannBasedMatcher**
  - cv.**BFMatcher_create**([, **normType**=cv.NORM_L2[, **crossCheck**=False]])
    → <cv.BFMatcher object>



normType: parámetro medida de distancia
- cv.**NORM_L1**, cv.**NORM_L2** -> SIFT, SURF
- cv.**NORM_HAMMING**, cv.**NORM_HAMMING2** -> ORB, BRIEF, BRISK

crossCheck : (bool) correspondencia valida si coinciden en los dos sentidos

- cv.**FlannBasedMatcher_create**() → <cv.FlannBasedMatcher object>



Por defecto precisa que el descriptor sea de tipo **CV_32F** **(np.float32)**

Para Descriptores **binaros** es preciso configurar los parámetros de la clase con el constructor por defecto:

- cv.**FlannBasedMatcher**([, indexParams[, searchParams]]) → <cv.FlannBasedMatcher object>

index_params = **dict**(algorithm = 6, table_number = 6, key_size = 12, multi_probe_level = 3)

Correspondencia Características: módulo features2D

- Ejemplo (**e7b.py**): extracción de características /matching
- Inicialización:

```
MATCHER_TYPE = 'bf'              # Default Feature Matcher bf/flann

# command line parameters
parser.add_argument('-m', dest= 'matcher', type=str, default= MATCHER_TYPE, metavar= 'matcher',
                                                        help= 'bf (BruteForce) | flann')
MATCHER_TYPE = parser.parse_args().matcher.lower()          # feature (lowercase)
```

```
# Init Feature Matcher
if MATCHER_TYPE == 'flann':
  if FEATURE_TYPE == 'orb':   # Binary descriptor -> NORM_HAMMING
      index_params = dict(algorithm = 6, table_number = 6, key_size = 12, multi_probe_level = 3)
      matcher = cv.FlannBasedMatcher(index_params)
   else:
      matcher = cv.FlannBasedMatcher_create()

else:   # Brute Force Matcher
   if FEATURE_TYPE == 'orb':   # Binary descriptor -> NORM_HAMMING
      matcher = cv.BFMatcher_create(normType=cv.NORM_HAMMING, crossCheck=True)
   else:                              # Scalar descriptor -> NORM_L2
      matcher = cv.BFMatcher_create(normType=cv.NORM_L2, crossCheck=True)

print(f"{MATCHER_TYPE=}")
new_reference = True          # Take new reference image
```

Correspondencia Características: módulo features2D

- Ejemplo (**e7b.py**): extracción de características /matching
- Procesamiento:

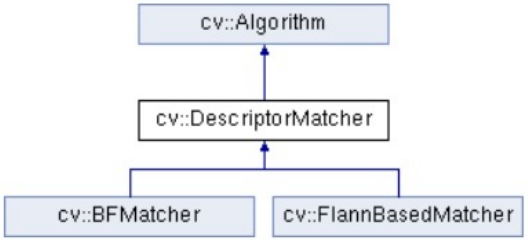
```
# processing section (image capture loop)
gray_image = cv.cvtColor(capture, cv.COLOR_BGR2GRAY)

keypoints = detector.detect(gray_image)
keypoints, descriptors = detector.compute(gray_image, keypoints)
```

Correspondencia Características: módulo features2D

- Ejemplo (**e7b.py**): extracción de características /matching

- Matchers: cv.**BFMatcher** (Brute Force) / cv.**FlannBasedMatcher**

- Componentes clase cv.**DMatch**:
  - **queryIdx*:* índice vector de descriptores 1 (cámara)**
  - **trainIdx*:* índice vector de descriptores 2 (referencia)**
  - **distance*:* distancia calculada entre vectores de descripción**



- Métodos clase cv.**DescriptorMatcher**:
  - cv.DescriptorMatcher.**match**(**queryDescriptors**, **trainDescriptors** [, **matches** [, **mask**]])
    → matches (list/tuple of cv.DMatch)

  - cv,DescriptorMatcher.**knnMatch**(**queryDescriptors**, **trainDescriptors**, **k** [, **mask**[, **compactResult**]])
    → matches (list/tuple of k-tuple of cv.DMatch)

    busca k vecinos más cercanos. Devuelve una lista/tuple, cada elemento: tupla de k cv.DMatch

  - cv.DescriptorMatcher.**radiusMatch**(**queryDescriptors**, **trainDescriptors**, **maxDistance** [, **mask** [, **compactResult**]])) → matches (list/tuple of k-tuple of cv.DMatch)

    busca vecinos a distancia maxDistance. Devuelve lista/tupla, cada elemento: tupla de k cv.DMatch

Correspondencia Características: módulo features2D

- Ejemplo (**e7b.py**): extracción de características /matching

- Bucle principal:

```
    .......

# Store reference on first frame or Reset
if new_reference:
    keypoints_ref = keypoints                # Tuples are inmutable so reference copy is valid
    descriptors_ref = descriptors.copy()     # Clone ndarray (avoid reference copy)
    image_ref = capture.copy()               # Clone ndarray (avoid reference copy)
    new_reference = False

# Match descriptors.
matches = matcher.match(descriptors, descriptors_ref)       # list of matches

# Sort matches in the order of their distance.
matches = sorted(matches, key=lambda x: x.distance)


    .......
```

Correspondencia Características: módulo features2D

- Ejemplo (**e7b.py**): extracción de características /matching
- Visualización Correspondencias:
  - cv.**drawMatches**(img1, keypoints1, img2, keypoints2, matches1to2, outImg [, matchColor [, singlePointColor[, matchesMask[, flags]]]]) → outImg
  - cv.**drawMatchesKnn**(img1, keypoints1, img2, keypoints2, matches1to2, outImg [, matchColor[, singlePointColor[, matchesMask[, flags]]]]) → outImg

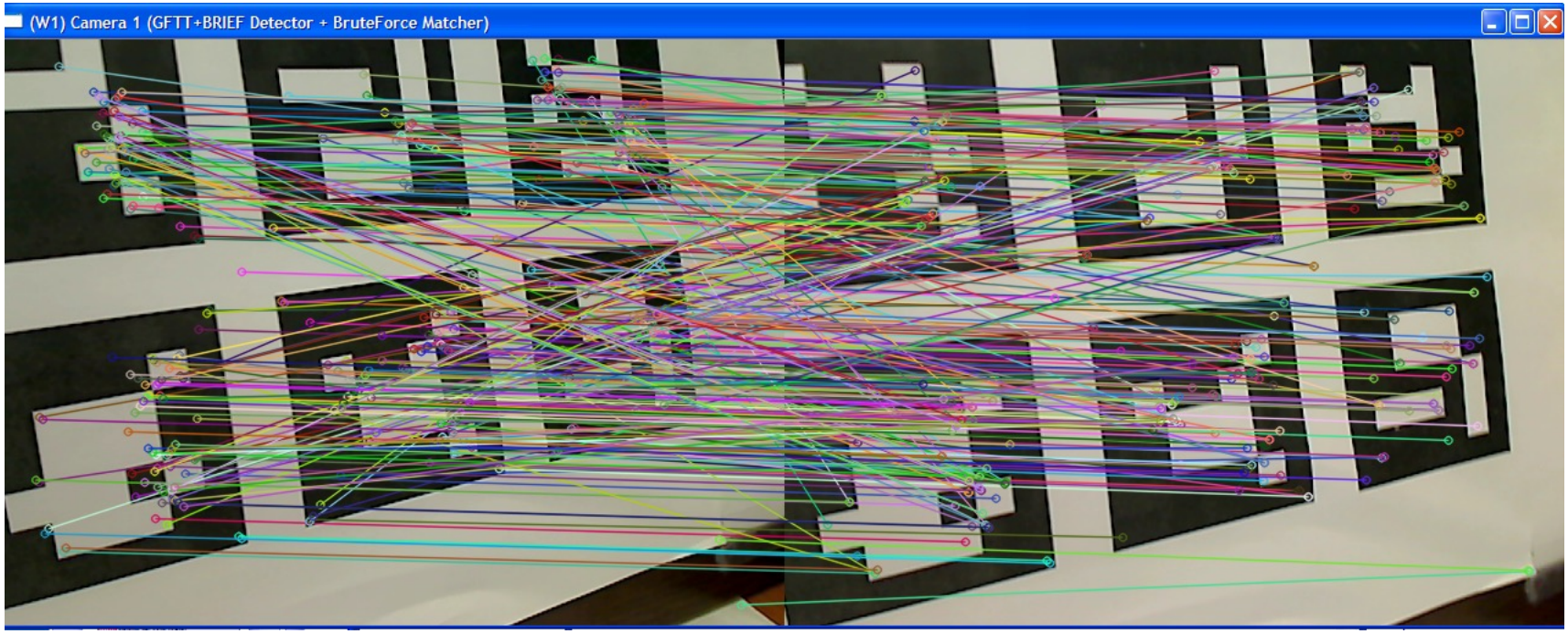
    - **flags**: cv.DRAW_MATCHES_FLAGS_DEFAULT, (crea outimage con image como fondo)
      cv.DRAW_MATCHES_FLAGS_DRAW_OVER_OUTIMG,
      cv.**DRAW_MATCHES_FLAGS_NOT_DRAW_SINGLE_POINTS**

```
# Draw first 20 matches.
dispimage = cv.drawMatches(capture, keypoints, image_ref, keypoints_ref,
                           matches[:min(20,len(matches))],  outImg=None,
                           flags=cv.DRAW_MATCHES_FLAGS_DEFAULT)

cv.imshow(WINDOW_CAMERA1, dispimage)     # Display matches

# check keystroke to exit (image window must be on focus)
key = cv.pollKey()
if key == ord('q') or key == ord('Q') or key == 27:
    break
elif key == ord('r') or key == ord('R') or key == ord(' '):
    new_reference = True     # Reset Reference image
```

Correspondencia Características: módulo features2D

- Ejemplo (**e7b.py**): extracción de características /matching
- Mostrar correspondencias:

```
# show matches on console
print(f"Left image points: {len(keypoints)}  - Right image points: {len(keypoints_ref)}")
print(f"Matched points: {len(matches)}")

for i in range(min(10,len(matches))):
    print(f"-- Match [{i}] Keypoint Cam: {matches[i].queryIdx}", end='')
    print(f" -- Keypoint Ref: {matches[i].trainIdx} -- dist: {matches[i].distance}")
```



CORRESPONDENCIA CARACTERÍSTICAS

Módulo features2D. (e7c.py)

- Correspondencia entre dos cámaras
- knnMatch() obtener k correspondencias
- Radio test: compara las dos mejores

Correspondencia Características: módulo features2D

- Ejemplo (**e7c.py**): correspondencia entre dos cámaras

```
CAMERA_ID = [0, 1]                  # camera ids

# check command line parameters
parser.add_argument( '-c',  dest='cameraID',  type=int, default=CAMERA_ID[0], metavar='id',
                                        help='camera id')
CAMERA_ID[0] = parser.parse_args().cameraID
CAMERA_ID[1] = parser.parse_args().cameraID + 1
```

```
# Init cameras
cameras = [ ]
for id in CAMERA_ID:
        camera = cv.VideoCapture(id)
        if not camera.isOpened():
            print("you need to connect a camera, sorry.")
            exit()
        cameras.append(camera)
```

```
# free camera resources
for camera in cameras:
        if  camera.isOpened():  camera.release()
```

Correspondencia Características: módulo features2D

- Ejemplo (**e7c.py**): correspondencia de dos cámaras
- Procesamiento para cada cámara:

```
while True:
    # Capture frame-by-frame
    captures = [ ]
    for camera in cameras:
        ret, capture = camera.read()
        if ret: captures.append(capture)

          ….
    gray_images = [ ]
    for capture in captures:
        gray_image = cv.cvtColor(capture, cv.COLOR_BGR2GRAY)
        gray_images.append(gray_image)

    keypointsList = [ ]
    descriptorsList = [ ]
    for gray_image in gray_images:
        keypoints = detector.detect(gray_image)                    # Tuple of keypoints
        keypoints, descriptors = detector.compute(gray_image, keypoints)

        keypointsList.append( keypoints )
        descriptorsList.append( descriptors )
 ……..
```

Correspondencia Características: módulo features2D

- Ejemplo (**e7c.py**): correspondencia de dos cámaras
- Visualización correspondencias:

```
# knnMatch descriptors. list/tuple of k-tuple of matches
matches = matcher.knnMatch(descriptorsList[0], descriptorsList[1], k=2)

# Apply ratio test to the two best matches
goodMatches = []
for m1, m2 in matches:      # tuple with two elements k==2
    if m1.distance/m2.distance < 0.75:
        goodMatches.append(m1)

# Sort matches in the order of their distance.
matches = sorted(goodMatches, key=lambda x: x.distance)

# Draw first 20 matches.
dispimage = cv.drawMatches(captures[0], keypointsList[0], captures[1], keypointsList[1],
                matches[:min(20,len(matches))],  outImg=None, flags=cv.DRAW_MATCHES_FLAGS_DEFAULT)
```