Simple Content-based Information Retrieve System:
Application for Searching a Screenshot in a Video

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Language: Python
Environment: Python 3.6.6, with library OpenCV & NumPy

The aim of this application is to demonstrate basic elements in a Content-based Information Retrieve (CBIR) System. The application consists of two parts:

extractor.py
- Convent video to image frames for further processing [by OpenCV]
- Dividend each image to blocks
- Extract features for each block
  - color-based method which extracts the average intensity of red, green and blue.
  - 3 features are extracted for each block
  - each frame has 3 * (# of block) features
- Reduce the dimension of features by discrete cosine transform
  - each frame has 16 features after reduction
  - the features at are more important
- Save features of all frames in JSON

[Remark: Modern approach is using CNN to extract features.]

searcher.py
- Read features of all frames from JSON
- Build Octree using the top 3 features
- Save Octree in JSON for visualization
- Read image, and extract features
- Search features in Octree
- Compare features and tree's node. Distance function is mean square error.
- Return result

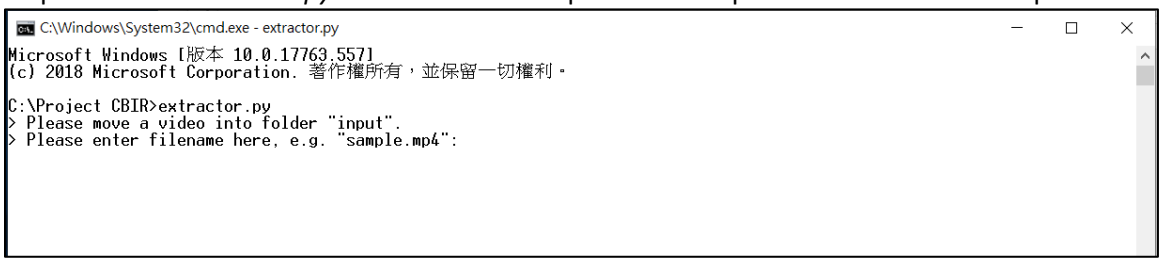
Note: Leaf nodes of search tree is (time, feature vector),
which is equivalent to (file path, file ID) in conventional search tree.

[Remark: Using R-tree would be more efficient.]*

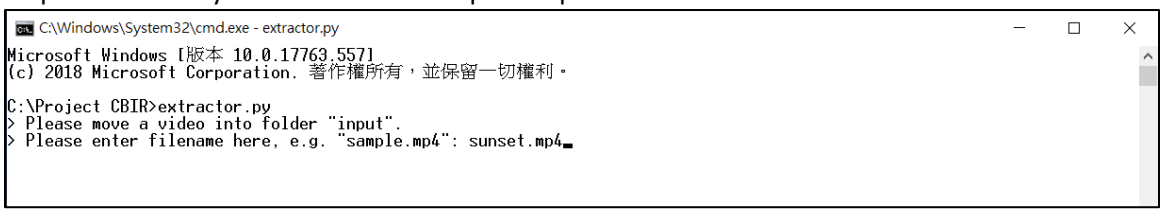
This application is modularized which allows to replace algorithms for
- **feature extraction (*feature.py)***
  [Now color-based method & discrete cosine transform are used.]
- **search tee & distance function *(searchtree.py)***
  [Now Octree tree & Mean Square Error are used.]

Demo:

Step 1.1: Run *extractor.py* and two folders “input” and “output” are created in same path.

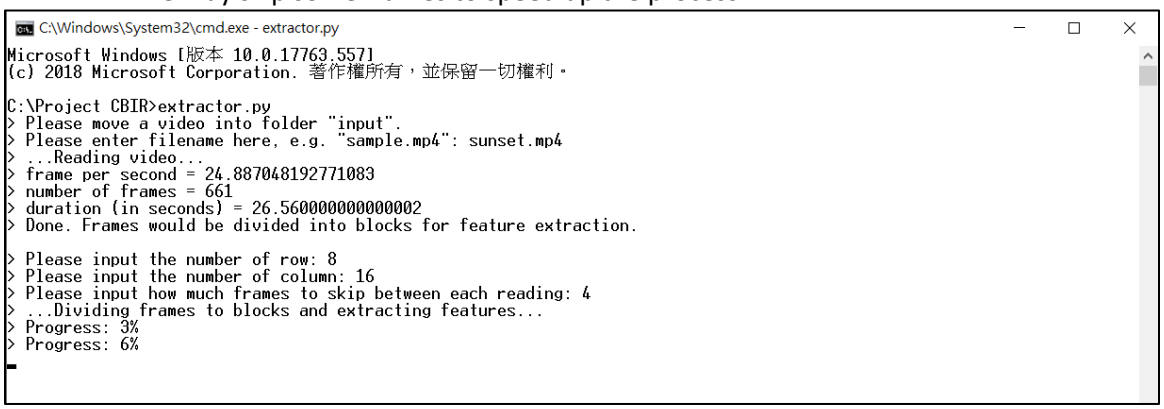


Step 1.2: Put any video into folder “input”. Input file name of video here.

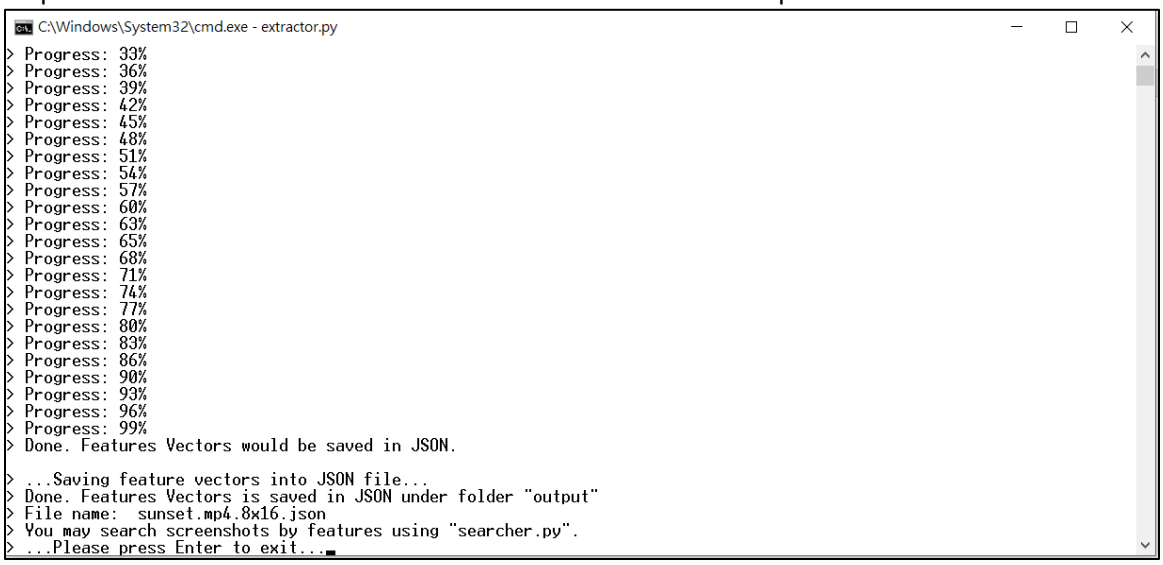


*In this demo, video is downloaded from **pexel** which allows free to use.*
License: https://www.pexels.com/photo-license/

Step 1.3: Video is transformed to frames.
[Important! Script is not optimized which consumes a lot of computer resources.]
Each frame will be divided into blocks for features extraction.
Enter the rows and columns to decide the number of blocks.
We may skip some frames to speed up the process.



Step 1.4: Features are extracted and save in JSON in folder “output”

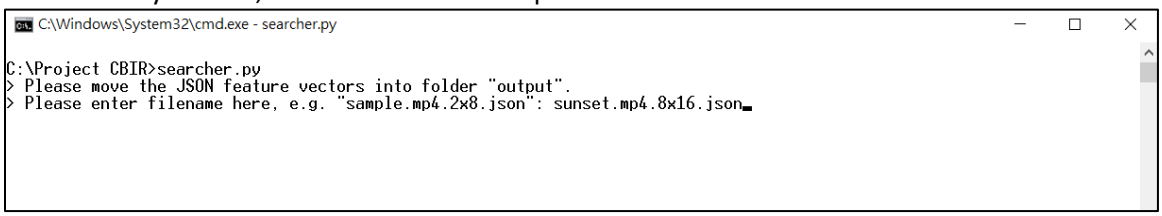


Example of JSON Feature vectors:

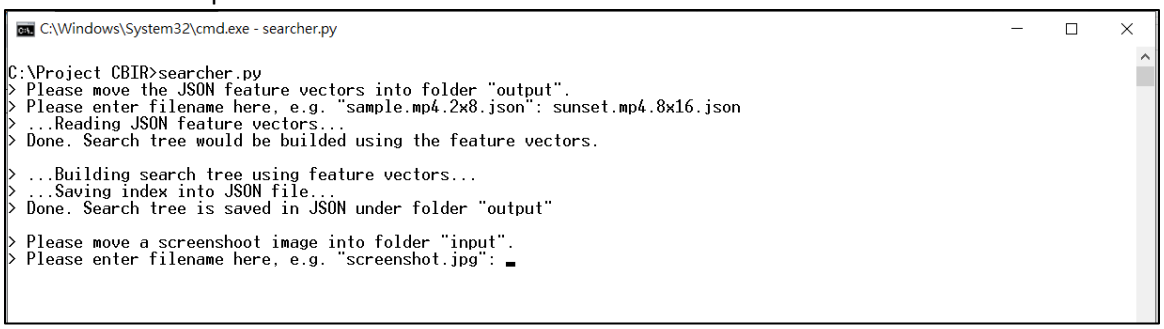

```
[
[0.0, [2301, -387, 81, -31, 73, 36, -40, -37, -30, -14, 16, -24, 1, -25, 17, -24]],
[0.20090771558245085, [2309, -393, 69, -20, 63, 52, -44, -36, -32, -17, 15, -20, 3, -17, 18, -19]],
[0.4018154311649017, [2307, -399, 51, -7, 51, 62, -46, -38, -35, -20, 12, -16, 3, -8, 17, -13]],
[0.6027231467473525, [2312, -401, 28, 11, 36, 72, -50, -38, -36, -22, 11, -9, 1, 0, 14, -10]],
[0.8036308623298034, [2315, -400, 2, 27, 19, 78, -55, -35, -37, -20, 7, 0, -1, 7, 9, -4]],
[1.0045385779122542, [2324, -395, -25, 42, 5, 77, -55, -33, -31, -20, 8, 1, 0, 10, 5, -1]],
[1.205446293494705, [2303, -391, -45, 47, 1, 70, -48, -39, -16, -24, 15, -3, 6, 1, 7, -6]],
[1.406354009077156, [2303, -385, -66, 54, 1, 62, -37, -46, -1, -28, 21, -11, 16, -6, 11, -12]],
[1.6072617246596068, [2315, -376, -83, 60, 5, 53, -28, -55, 5, -27, 21, -12, 20, -9, 13, -16]],
[1.8081694402420576, [2319, -361, -99, 61, 14, 42, -18, -68, 11, -27, 18, -8, 17, -2, 10, -14]],
[2.0090771558245084, [2320, -351, -114, 58, 23, 29, -8, -80, 11, -26, 12, -1, 14, 7, 7, -11]],
[2.2099848714069594, [2318, -339, -129, 55, 32, 20, -1, -86, 5, -19, 0, 11, 8, 14, 6, -11]],
[2.41089258698941, [2298, -324, -143, 54, 30, 19, -3, -84, 0, -15, -7, 13, 1, 18, 2, -4]],
[2.611800302571861, [2291, -307, -151, 50, 31, 18, -4, -78, -7, -6, -14, 16, -2, 18, 2, -8]],
[2.812708018154312, [2285, -297, -154, 38, 40, 16, -6, -71, -15, 3, -22, 15, 0, 10, 12, -16]],
[3.0136157337367626, [2291, -291, -156, 28, 47, 16, -6, -69, -15, 11, -21, 8, 10, 0, 19, -15]],
[3.2145234493192136, [2297, -280, -156, 18, 54, 14, -9, -66, -13, 14, -16, 3, 16, -3, 25, -17]],
[3.415431164901664, [2326, -270, -161, 7, 60, 15, -15, -62, -9, 14, -7, 0, 18, -1, 27, -16]],
[3.6163388804841152, [2339, -263, -161, -6, 66, 15, -19, -59, -4, 10, 2, -4, 21, 2, 25, -8]],
[3.8172465960665662, [2360, -256, -165, -14, 66, 16, -20, -60, 0, 9, 4, -2, 17, 7, 21, 2]],
[4.018154311649017, [2381, -252, -167, -17, 60, 23, -21, -59, 0, 11, 4, 4, 13, 12, 18, 11]],
[4.219062027231468, [2385, -249, -169, -23, 56, 27, -20, -59, 0, 13, 7, 6, 14, 13, 17, 14]],
[4.419969742813919, [2378, -240, -166, -28, 48, 28, -18, -56, -3, 20, 11, 5, 15, 15, 16, 15]]
]
```


- Feature vectors are in format *(time, 16-dimension reduced feature vector)*

Step 2.1: Run *searcher.py* and enter file name of JSON feature vectors
By default, the JSON file is in “output” folder.



Step 2.2: Octree is built using the feature vectors. The tree is saved in “output” folder.
The top 3 elements for feature vectors are used as coordination in Octree.

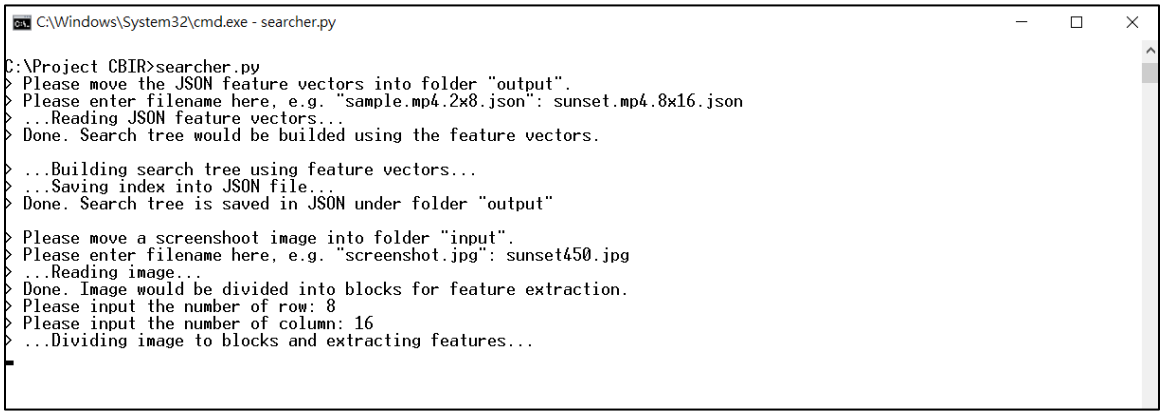


Example of JSON tree:

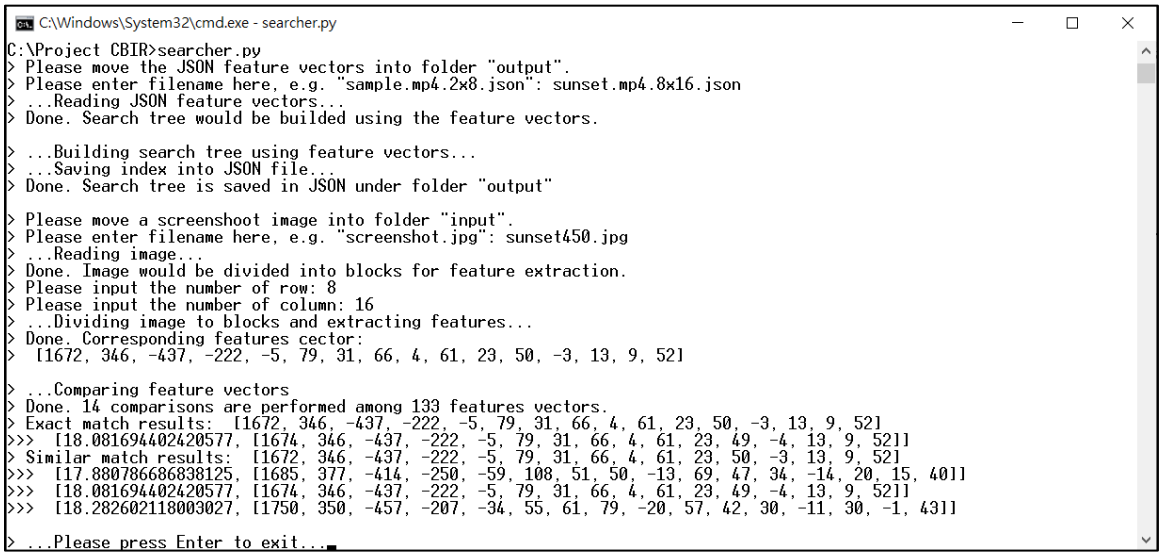

```
[
    [false, 97, -401, -472, 2772, 702, 81, 8],
    [
        [true, 97, -401, -472, 1434.5, 150.5, -195.5, 11]
    ],
    [
        [false,97, -401, -195.5, 1434.5, 150.5, 81, 8],
        [
            [true, 97, -401, -195.5, 765.75, -125.25, -57.25, 11]
        ],
        [
            [true, 97, -401, -57.25, 765.75, -125.25, 81, 11]
        ],
        [
            [true, 97, -125.25, -195.5, 765.75, 150.5, -57.25, 11],
            [23.7071104387292, [393, 77, -60, -34, -25, 11, 15, 23, 1, 11, 2, 14, 1, 9, 1, 13]],
            [23.50620272314675, [460, 93, -75, -49, -29, 14, 21, 26, 1, 10, 2, 17, 1, 12, 0, 16]],
```


- It is a node with 3 levels.
- Header of a node represents *[*
  isLeaf: Bool,
  xLowerBound: int, yLowerBound: int, zLowerBound: int,
  xUpperBound: int, yUpperBound: int, zUpperBound: int,
  maxChild: int]
- If it is a root or intermediate node, the Boolean is *FALSE*. The maximum number of children equals to 8. All children are nodes.
- If it is a leaf node, the Boolean is *TRUE*. All children are feature vectors. Given it is an Octree, some leaf nodes may have no children.
- Searching is performed using [x, y, z] coordination, or in other words, the top 3 features.
- Retrieved data is time, which means file path for an video.

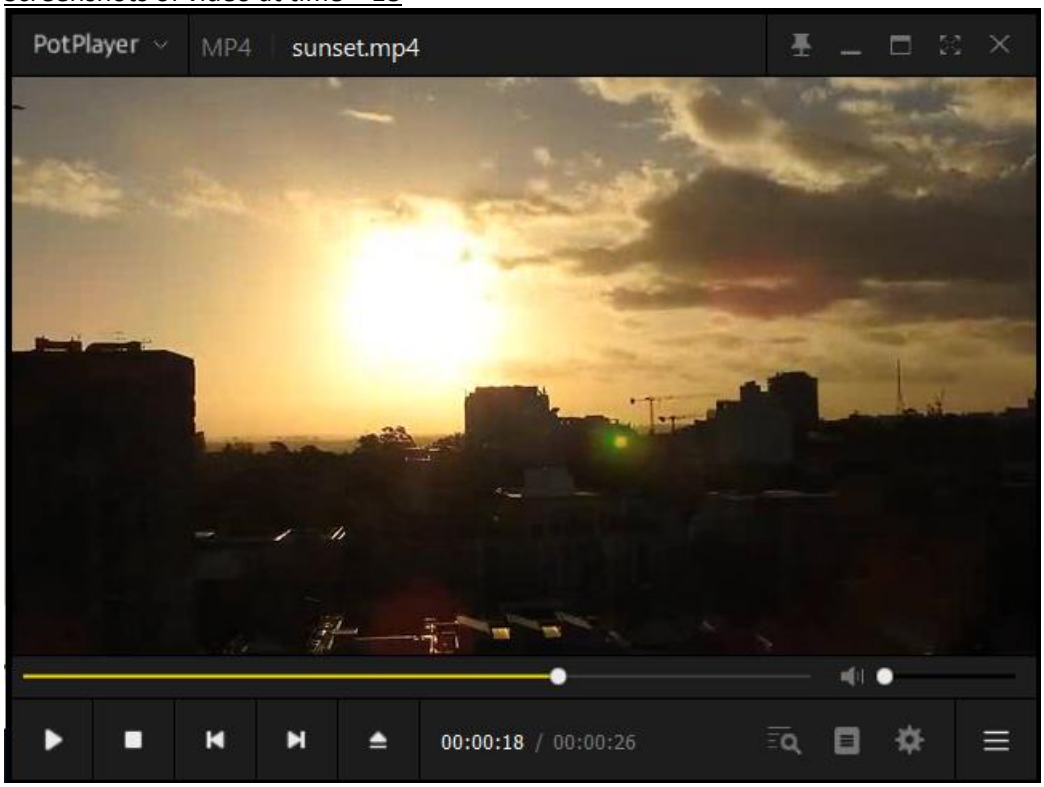
Step 2.3: Put a screenshot image into folder “input”.
Enter the file name to extract image’s features.
Also enter number of rows and columns for feature extraction.



Step 2.4: Searching result is displayed.
For below example, 14 comparisons are performed to find matched result.
The screenshot could be found at around 18 seconds.



Screenshots of video at time = 18



Screenshot input for searching

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