Unofficial manual version 2.0

September 2018

If you have no idea about this work, please start from the paper
https://arxiv.org/abs/1803.00788

All the code are stored in: C:\Users\CNNplace\Documents\MATLAB\Code
All 227x227 images are stored in:
C:\Users\CNNplace\Documents\MATLAB\SceneImage\OSM_MAPtest

Folder needed to be activate:
For OSM extraction: OSMprocess + johnyf-openstreetmap-v0.2.2-3-gbb37962
For OSM process: OSMprocess + Utility
For GSV/BING images download: OSMprocess + Streetview

Small tip: if you do not have any idea where I put the said functions or scripts, use the command **edit functionOrScriptname** or highlight the name in the file → right click → select 'open *filename*', and make sure you add all the path above before search it, if not, it will ask you whether you want to create a new file of not.

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Where to start

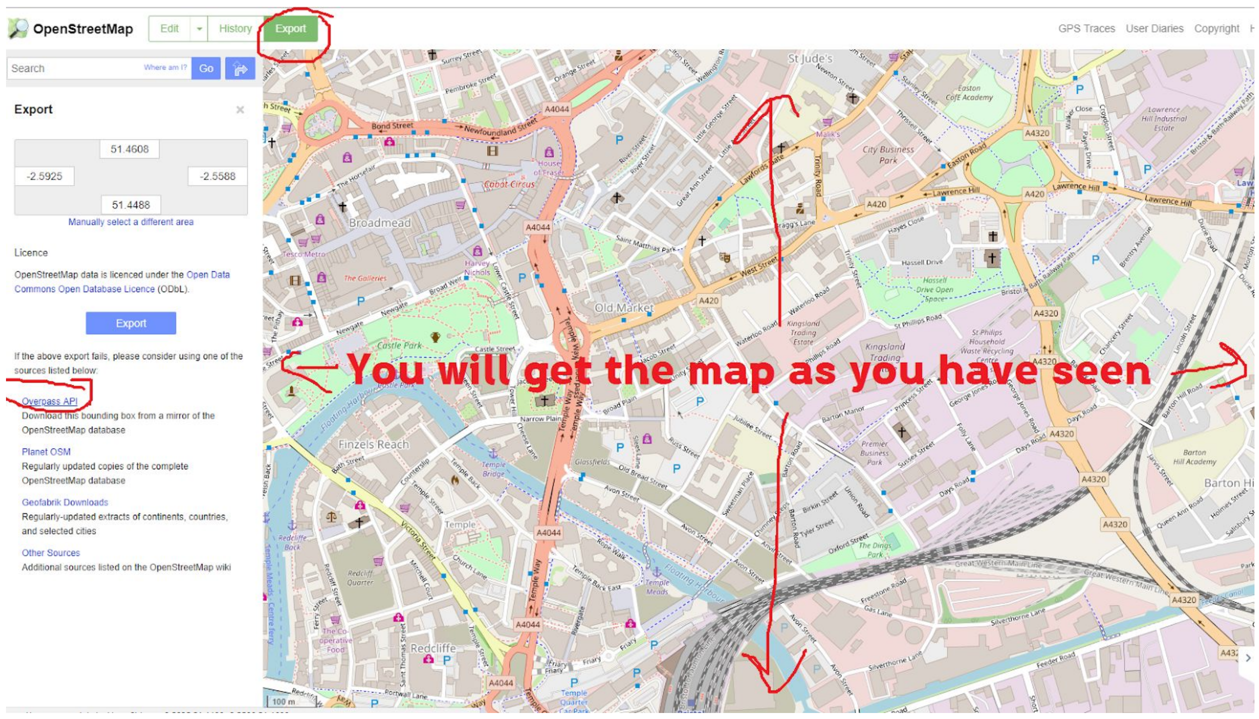
Within the code folder, go and check the **OSMprocess\1_BasicCommand** folder for the basic file. It contains these operations:

1. **Load OSM + corresponding GSV images + construct the static database (normal/dense)**

The basic processes are: read OSM, get the tag of each object, get road points, find intersection of road and generate connectivity table, for each point, interpret the OSM information, and then download the corresponding images from GSV.
After that the connectivity table will be used for generating the DB.

- Load OSM

To get .osm file, go to https://www.openstreetmap.org/ and select the region you want → press 'Export' → 'Overpass API'. Then rename the loaded file to .osm



Export

51.4608

-2.5925

-2.5588

51.4488

Manually select a different area

Licence

OpenStreetMap data is licenced under the Open Data Commons Open Database Licence (ODbL).

Export

If the above export fails, please consider using one of the sources listed below:

Overpass API
Download this bounding box from a mirror of the OpenStreetMap database

Planet OSM
Regularly updated copies of the complete OpenStreetMap database

Geofabrik Downloads
Regularly-updated extracts of continents, countries, and selected cities

Other Sources
Additional sources listed on the OpenStreetMap wiki

All of my .osm file are in:
C:\Users\CNNplace\Documents\MATLAB\Code\OSMprocess\osmcnn\mymap

I strongly suggest you to open some of them via any text editing tool to get the feel how OSM store and arrange the data. In brief, it is similar to XML. Try to avoid loading too large map, MatLab will crash.

Note: Make sure you check the appearance of the OSM map before download. Sometimes you'd see the blank city with only road; that means there is no information about the building at all, so you cannot use this for 'gaps between buildings detection' process as there is no building.

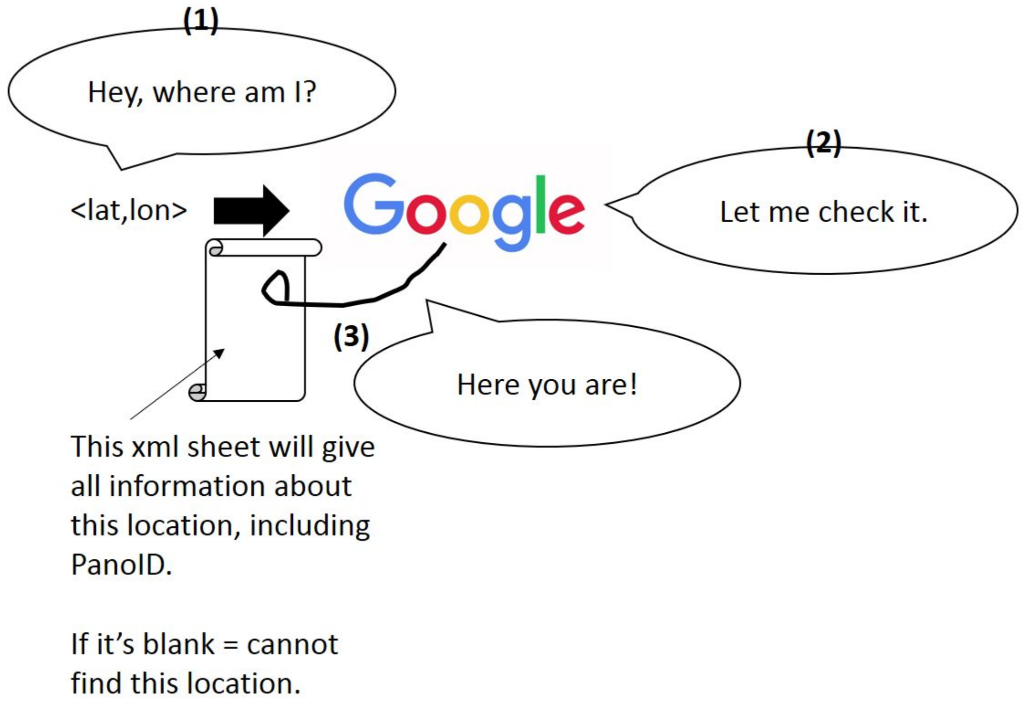
Also, you can check the tag and label I used from **OSMtagSetupInit**. Be careful if you would like to try to load OSM of non-english usage country, there might be a problem caused by the label. I had tried Japan before and found out that my code could not work due to the face that the OSM map contains Japanese label and my function cannot read it.

For descriptor generation, you can go and check **osmggg\getGGAngletoLines** and modify it to check the finer angle.

Note: the road intersection detection still contains some I-do-not-know-why-it-happened bug. It's not usual, but can occur, so go and check: **getRoadConn** and **conRoadTableConn**, you might find where I missed. The effect of this bug is sometime the connection looks funny, they jump to the next road. This probably might cause by the raw OSM.

- **Load Google Streetview**

The concept of Google streetview is you send the <lat,lon> → get Panoramic ID of that panorama and then select where to crop out.


(1)
Hey, where am I?
<lat,lon>
Google
(2)
Let me check it.
(3)
Here you are!
This xml sheet will give all information about this location, including PanoID.
If it's blank = cannot find this location.

The process from 1-3 are in **Streetview\src\streetImagery\checkUsageLL**. If you'd like to get more information, go and modify it. I read XML as a text and retrieve the strings I want. Then, from this you can get the corresponding PanoID and send to Google again with some parameters to retrieve the image. In my code, the important information will be stored in **pList**, which is a sub-parameter in **osmelem**.

Also, go and check **osmretrieveggg4_NEWSMALL** for more information. Note that I have two separate folder for saving the large images (1240x480) and cropped images (227x227). However, for the future test, <u>do the train by capture in 227x227 directly</u>. No need to keep in two separate location. To change this, just get the input for sizeIm2 = [227 227] and remove the cropped part & filepathS variable from the function.

Note that sometimes by running the GSV scripts/functions in the different time, you might get the different number of GSV-uniqued road. If there is a crash like the data cannot be download, maybe you should stop and wait for another day. Sometimes there will be a weird crash like this using Google API.

There is also the Bing version, check **realZhu\BING\osmretrieveBBG4_NEWSMALL** to see how I download images. The basic process of Bing is similar to Google. Also, there are some other useful functions that you can use all in **Streetview** folder. This is the legacy code, so there are things that I have not discovered yet.

Also, on the web, you can get the PanoID from the URL:

https://www.google.com/maps/@51.4568999,-2.6021452,3a,75y,129.66h,93.02t/data=!3m6!1e1!3m4!1s**E0ej1HvN8dzkm3JK6HHbog**!2e0!7i13312!8i6656

The PanoID is **E0ej1HvN8dzkm3JK6HHbog**. It will be after !1s and before the next !, and the latitude and longitude are highlighted in red.

You can retrieve the XML information by copy and paste this to the web browser:
http://maps.google.com/cbk?output=xml&ll=51.4568999,-2.6021452

If you want to get the panoramic image, use:

I = downloadPanoImage(panoID, zoomfactor); %default = 3

For example, from osmelem parameter, you can call:

I = downloadPanoImage(osmelem.pList(1).panoID, 3);

There is also a way to get depth information from GSV in case you might need it; I cannot remember the exact function, but I believe you can find something useful in **\streetImagery\ggstreetview** folder.

- **Generate DB**

For DB, I would suggest you to try the normal construction first. Be careful when you use dense version, this one is not optimised, it could take days to generate the whole dataset. I encourage you to look for more practical solution.
In my code I set the sub-section = 4; you can adjust them as you like, or make it more flexible (for example, the auto-generate function/script that do the auto loop instead of manual like this). If you change the number, make sure to go and modify the search process.

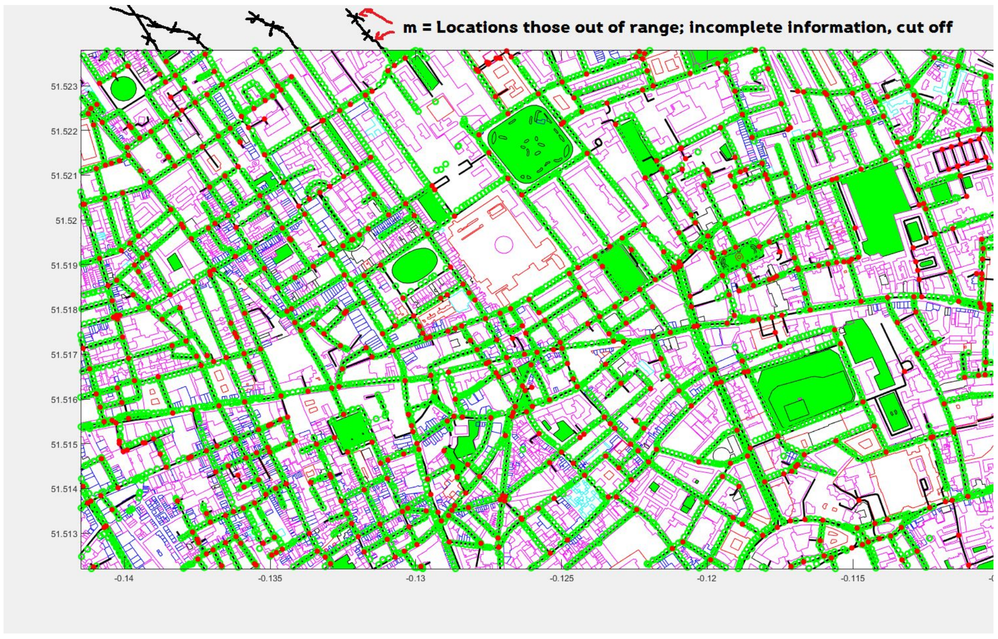
The database you could play with:
LONDON: I split into 4 sets; they are in the folder → **D:\TreeData\Set1 (Set2,Set3 and Set4)**
BRISTOL: this one is densed, so I split into ~6000; they are in the folder → **D:\TreeData\realZhu\FullPath_all**
Be careful, it's actually loaded.

Note that the generated routes are **not allow to perform revert direction** (for this version). You can (and should, in the future) add them by turning the direction of the descriptor. Please check **genFullBoxNew3** and **genFullBoxDesc** functions.

Also, please be careful about the format of the descriptor (binary/decimal). If you put it wrong, you might find that the accuracy of classifier looks very scary (like, 70% error!). Don't be panic! Carefully check the format first. For example, in **genFullBoxDesc**, you need to put the descriptor in the **decimal** format. You can modify them into a friendly version if you like; it is so easy to get confused.

Let say, for one location:
Raw format: 1 1 2 3; when 2 = 0 and 3 = unknown (sometimes the info on the map can be missing.)
Binary format: 1 1 0 0; I replace 2&3 as 0
Decimal format: 12

For the important parameters: *rconnTable* is the road connectivity table, *numHops* is the maximum number of locations within the route you need (try 40), *descList* is the list of the BSD descriptor for each location; in my database: *descList_n2* is the raw interpretation from the map *descList_n3* is the binary format, and *descList_n4* is the decimal format, and *m* is the number of locations those are out of range (says, some location might not appear on the map, and it means the data might be incomplete so I remove them off).



Go and check **OSMFirstprocess** for more information about how each parameter has been genereated.

2. Train the dataset

Each classifier trained separately. The data will be arranged into table format. For more details of using CNN in Matlab: https://www.mathworks.com/help/nnet/ref/trainnetwork.html

The processes of training are: (1) Generate table of labelled data and (2) Put the table into the

For junction use: *[T] = genTableData(filepath,ggSet);*
For gaps use: *[T] = genTableDataBDJC_cate(filepath,ggSet);*

When T is the generated table of labels, and filepath is the location of image corresponding to the ggSet. For ggSet, you generated them in the previous step (while extracting the OSM).
If you want to use my image data, go and check **C:\Users\CNNplace\Documents\MATLAB\SceneImage\OSM_MAPtest** folder, there are tons of it; their corresponding ggSet has been stored in the **C:\Users\CNNplace\Documents\MATLAB\DataBackup** folder and look for **_allGG** file (ex. 'C:\Users\CNNplace\Documents\MATLAB\DataBackup\20170413_BBLSM**_allGG**.mat'). It might be a bit hard to find. If it is too confused, and you need to re-download/retrain it anyway, just do the step 1 and make sure you properly save the ggSet parameter.

You can also rewrite everything, the training process is simple, you only need matlab table with 2 column: image path and label. For more information: https://www.mathworks.com/help/matlab/ref/table.html

Also, if you want to try on other semantic features, go and modify the way ggSet has been interpret the OSM map first and then move to the genTableData for modification,

To test it, follow the code in testing section. Note that I am not sure whether this one is the newest version or not. You can also write a simple function to check the results. The easiest way is to turn the test set into the table, put the image into the classifier by:

```
I = imread('Your file path'); %Optional I = imresize( imread('Your file path'), [227 227]);
res = predict(net,I);
```

The res parameter will return the score for each category, you can add *ans_cate = find(res == max(res));* to get the answer. In my work, 1 = junction 2 = no junction, and the same as gaps. To turn the answer to binary, convert 2 into 0.

Then, compare the returned result with the label (ground truth) and count the accuracy.

Note: again, I would suggest you to be careful with the size of the training set; having too large would freeze the machine (look at ***'MaxEpochs'*** and ***'MiniBatchSize'*** parameter). Don't panic, just restart the computer and try again with a smaller size.

Also, there is some ways you could obtain the backup for each round of the training. From my setting, see the parameter ***'CheckpointPath'***, in the demo, I put them in ***'D:\checkPoints'***. You can change it to any directory you prefer. This is also loaded, you should go and clear them when you don't want them anymore.

For more information about the training process using MatLab, please read:
https://www.mathworks.com/solutions/deep-learning/convolutional-neural-network.html
The examples are good. Make sure you understand it.

For my trained networks in both categories, go for
load('C:\Users\CNN*place**Documents*\MATLAB*DataBackup*\20180330_NET*only*')

3. Sampling + Test + Results

Note: andddd again, I would suggest you to be careful with the size of the test set; having too large would also freeze the machine. The smart move is 25 or 50, and then you can run several times to gain numbers.

SamplingAndSearch is the the naive version (run from 2-40 big BD)
SamplingAndSearch_DYNM is the dynamic version; it would start by searching on the full database, but at some points, it will stop and use the previous results as the base to generate the new database. Change the number as you like. I would suggest 10-15 depends on the size of dataset & the accuracy. Too low would cause the fail to detect the correct route.

*[Edited] I found some minor bugs for dynamic version and do not have time to fix *sorry*, but the core function should be okay, you can start by that.*

While searching, if the program just closes itself (or crash/ get debug prompt) without any sign, I advise you to check the balance of the descriptor and the location you load the DB file. The common problem is the size of descriptors in the database is not the same as you query; this is the crash of c program. Another possibility is the wrong length of threshold list (ex. You test for 50 keys but put 40 threshold list).

This part still opens for the optimisation process. I'm sure it could do faster.

Note that the turn process has been included after the search, you can find the code in there.

Also, you can change the angle of the turn as you like; one difference from the paper is that I had changed from turn/not turn to left and right turn. However, I changed this and that a lot to see the response, and I am not sure which version I left. You might want to ensure the correctness of the function.

Please keep in mind that sometimes Google frontal angle might have an error (ex. → → ← → → ; one location gets reverted frontal angle). I have not remove this yet as it is not a major problem at this state of work. However, in real world environment, this might affect your result when applying the turn direction process (as this might cause a fake turn). I'd suggest you to find a way fix this. Small tips: check the direction along a route to see the sudden changes and flip the image + viewing position.

4. Visualisation (one route operation only)

Inside basic folder, check **New_testConcl\demoDisplayCC**, these are the basic operation of visualisation. To change the value, you can check each function. Sorry for some hardcode and magic number; I'd tried my best to reduce them.

The **convertScores_frameCCGT** is the ground-truth integration; this one will guess the current location by using the information from the previous steps. The original is counting the n-consecutive overlapped routes.Says, if they appear to be the best answer around the same location for n times, we guess that'd be our current location.

Sorry that I cannot find the old version, it should be somewhere in my code. This one is the modified version, so it might be slightly different operation, but you can do the modification based on this; it is kind of straight-forward process. I left the test route for you. If you would like the new one, you can generate from step 3.

Also, there is a way to perform all the animation in one frame. Use loop and **pause command**. For example:

```
for numHops = 1:39

if numHops > 1 %not the first round
  %Remove the handle of the previous round
  delete(AJ);
  delete(SJ);
end

[AJ,SJ] =
displayBKCCC_anim_IN(mroadcoord2,convAns2,pathSet2,thresSet(keynum,numHops),numH
ops); %Go to take a look, the basic operation is similar to my example code

pause(1); %You can set the time as you like

end
```

To save frame by frame, you can call:

```
temp=['Your file path\frame',num2str(keyframe),'.png'];
saveas(gca,temp);
close(gcf); %This will close the current frame
```

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Some useful functions

To calculate the distance between two coordinate points: dist = **distFrom**(coord1,coord2);
To calculate the size of the whole OSM area: [w,h] = **getOSMboundM**(osmelem.bounds);
To see the whole OSM map: **displayOSMinit**(osmelem)

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Small tips

I'm sure that you would see a lot of 'crash' or 'freeze' in this document. It is because each process is memory consuming; try not to open the other programs or run things in parallel to reduce the memory usage.

Please bear in mind that you should to save as much as possible to ensure you won't need to re-do them, especially the training process; Losing something that you train for 2 days is not fun at all. Also, I'd love to suggest you to try to do things in script instead of function because if the function crashes, you cannot take out the intermediate results and need to re-run from the start.

If you are more familiar with other languages, switching to other tools might be much better and more stable (but, yes, you need to rewrite everything).