Course Name: Species Distribution Modelling *(SDM).*
Software: *Digitize IT.*
Module: *Pixel Classification and Geo-referencing.*

Next Steps (from Object Detection):

The output of the object detection module are the maps that had similar pixel intensity values with the template images. This is in the ideal case. Normally, the output of cross correlation might have unwanted texts, blank images or any other noises. These are common problems with the algorithms that work on threshold values. These issues will be addressed later, but for now choose the best possible maps and delete the rest of the unwanted maps manually.

Now, you should have a folder containing all the proper maps which will be given as the input to the next module called pixel classification.

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Pixel Classification

Introduction:

Template matching detects the maps in the scanned input images, but in order to analyze the details within these maps, the legends have to be identified and detected. Identifying these legends based upon the contrast, shape and color in the maps is called pixel classification.

Pixel Classification Algorithms:

Pixel classification takes place in two steps:

1) Pixel Matching.
2) Edge and contour detection using filters.

1) Pixel Matching:

The images in the figure 1 represent the template images from the legend elements. All the legend elements except the dark circles are detected through this method. The set of template legend images are matched with the elements in the input maps. The workflow of the pixel matching algorithm is similar to the template matching algorithm. A set of input template legends are randomly cross correlated with the input images.

The below images are the pixel templates that are extracted in the same way the template maps are extracted through the DD-R Shiny application.

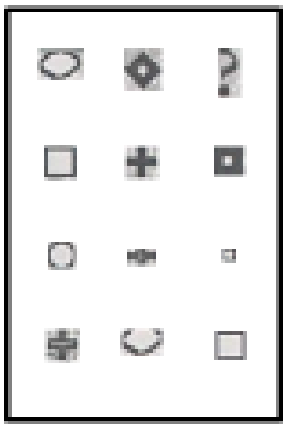

Fig 1: *Pixel Templates.*

Note: *Except the dark circles all other legend images are extracted through this method. For now skip the dark circles, which will be extracted in the next algorithm.*

Example: *Pixel classification in the maps from the book, "Butterflies of Pakistan", Threshold Value = 0.9.*

Output:

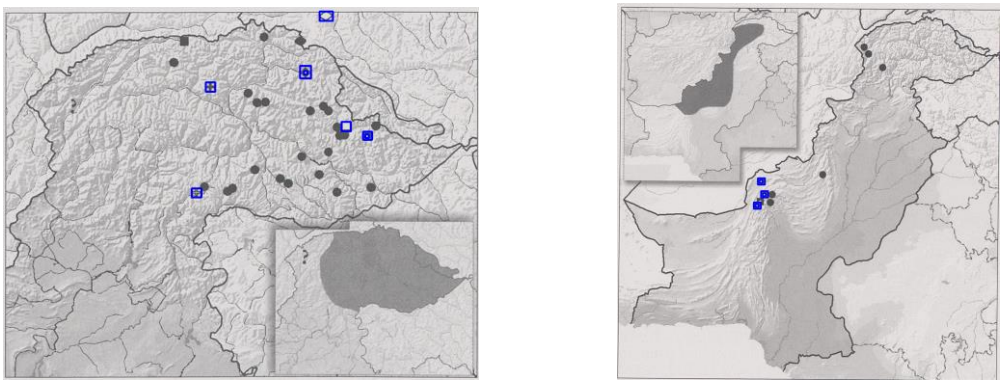

Fig 2: *Outputs of Pixel Classification.*

2) Edge and contour detection using filters:

The filtering of images through edge and contour detection is as follows:

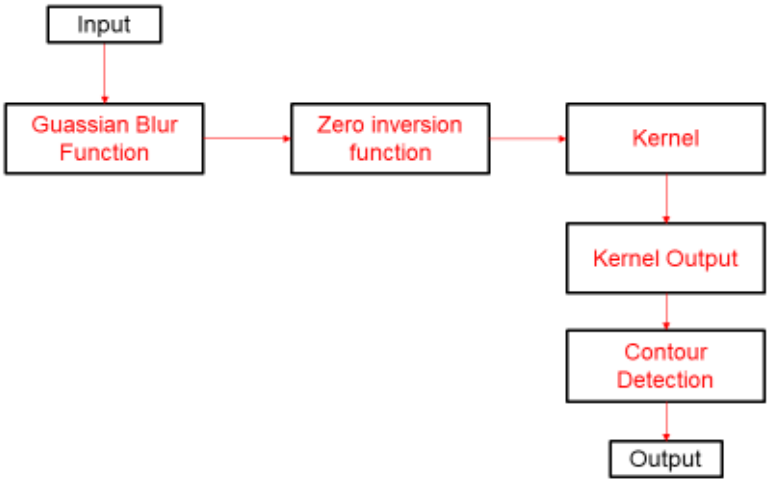

Fig 3: *Workflow of Edge Detection.*

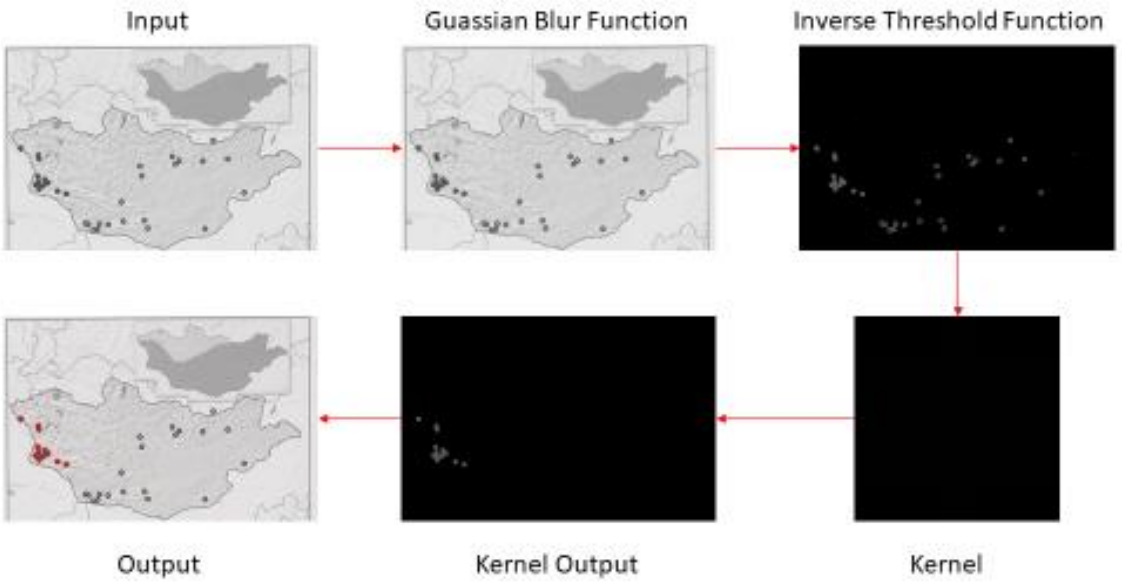

Fig 4: *Workflow of Edge Detection with consecutive outputs.*

The input image is the cropped raster map obtained at the output of template matching, this is sent to Gaussian blur function, Otsu Inverse Threshold function, Kernel Convolution, and Contour detection for further pixel classification.

$$\frac{1}{273}\begin{bmatrix} 1 & 4 & 7 & 4 & 1 \\ 4 & 16 & 26 & 16 & 4 \\ 7 & 26 & 41 & 26 & 7 \\ 4 & 16 & 26 & 16 & 4 \\ 1 & 4 & 7 & 4 & 1 \end{bmatrix}$$

Fig 5: *Gaussian Filter.*

Gaussian Filter:

The Gaussian smoothing operator is a 2-D convolution operator that is used to `blur' images and remove detail and noise.

The Gaussian blur takes the sum of all the pixel values in the Gaussian function and then divides them by the total pixel value. For example, in the case of the figure 5, the total value of pixel intensity is 273 and hence it divides pixel intensity at each and every array by 273.

Otsu Inverse Threshold function:

In Otsu Threshold function, the threshold is determined through the histogram of the pixel intensity values automatically and all the white points or the points that have lesser intensity value than the threshold are blurred or filtered.

Kernel:

A kernel, convolution matrix, or mask is a small matrix used for blurring, sharpening, embossing, edge detection, and more etc.

Kernel Output:

This is the output of convolution between the kernel and the input image. Here, only the dark or high pixel intensity values pass through because of the high value kernel matrix.

Output with contour detection:

The contour detects the edges of the points from the output of kernel convolution and starts constructing it in the input image and at the end of the process, all the dark circles will be covered.

Overall Workflow of Template Matching:

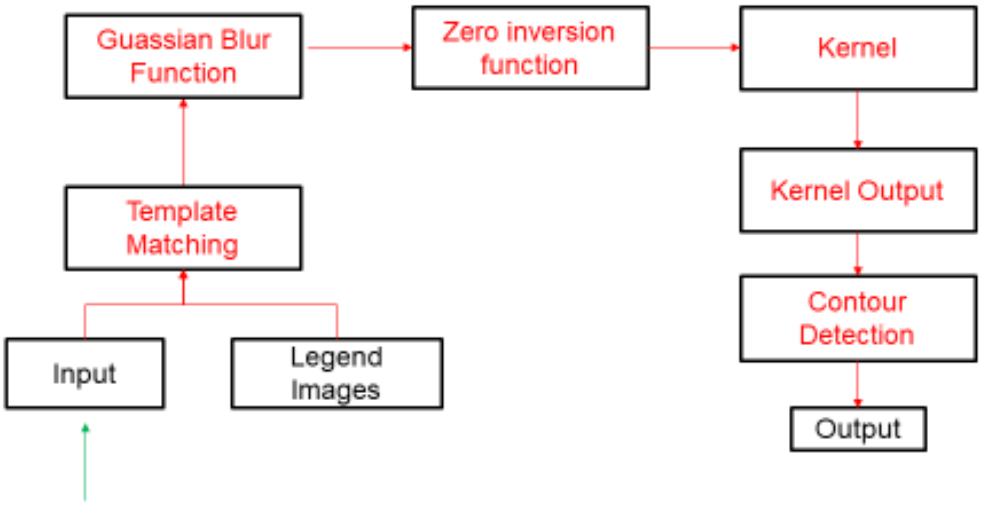

Fig 6: *Combined Workflow of Edge Detection and Pixel Matching.*

Outputs of Pixel classification (Together with both the algorithms):

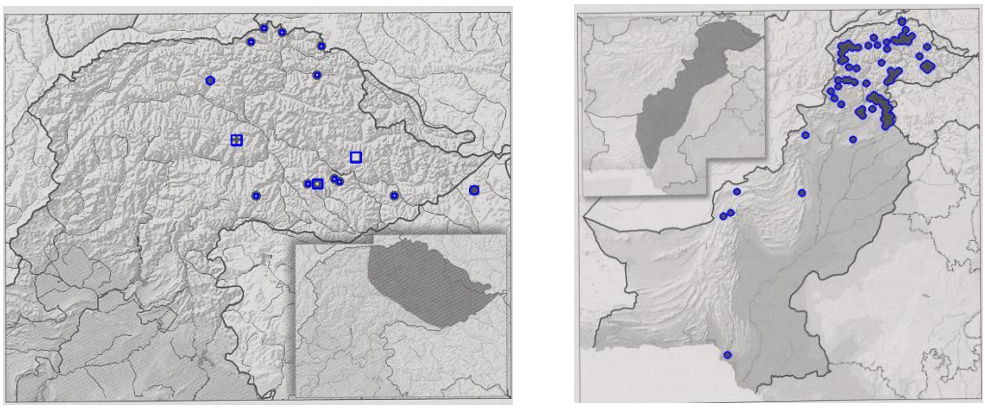

Fig 7: *Workflow of Edge Detection with consecutive outputs.*

Tasks:

1) Classify the pixels for the images obtained as the output of Object Detection module.

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Geo-referencing

Converting the Cartesian coordinates in the map into geographical coordinates to extract the real time location of the species is called as Geo-referencing.

Software:

Geo-referencing is done through the QGIS Software which is an open source and free software.

Link for downloading QGIS (Version > 3.0 and Standalone installer is highly recommended):

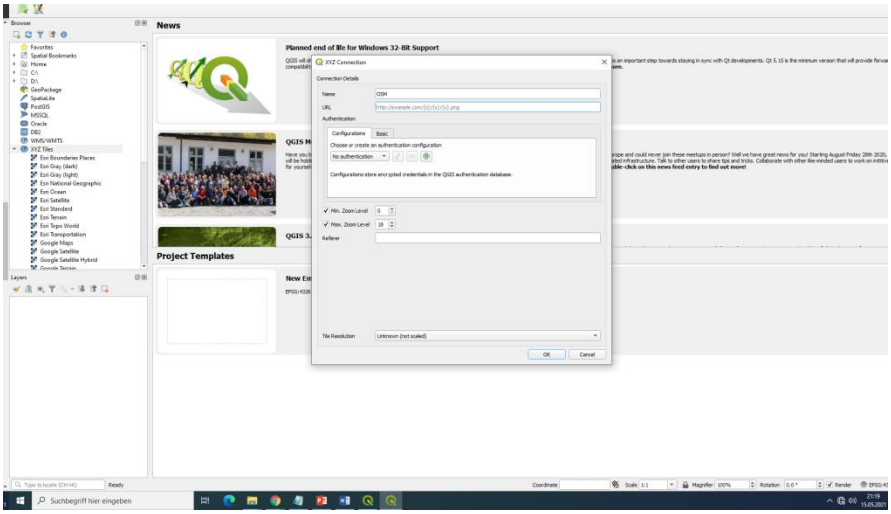
https://qgis.org/en/site/forusers/download.html

Load the Open Street Map (OSM) in QGIS: *https://tile.openstreetmap.org/{z}/{x}/{y}.png*

Recommended EPSG: *102025 (Important).*

Tutorials for the functions in QGIS:

Step 1: Right click on the XYZ Tiles (available on the left side scroll window of the QGIS page) and select new connection. Under new connection, copy and paste the link of OSM as shown in the below image.



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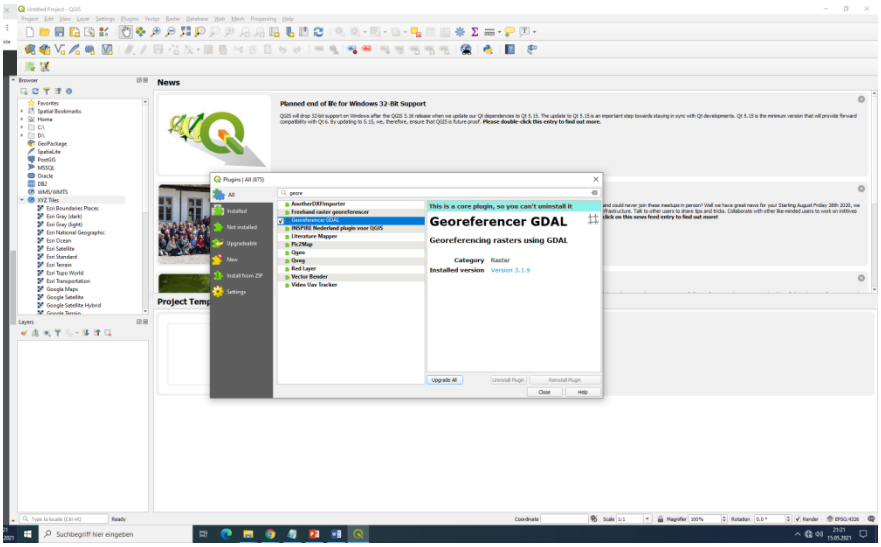
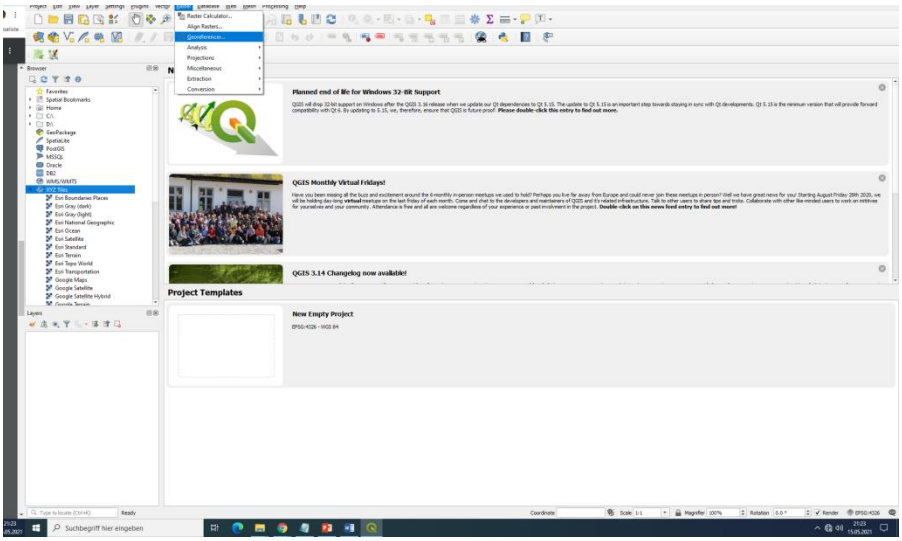
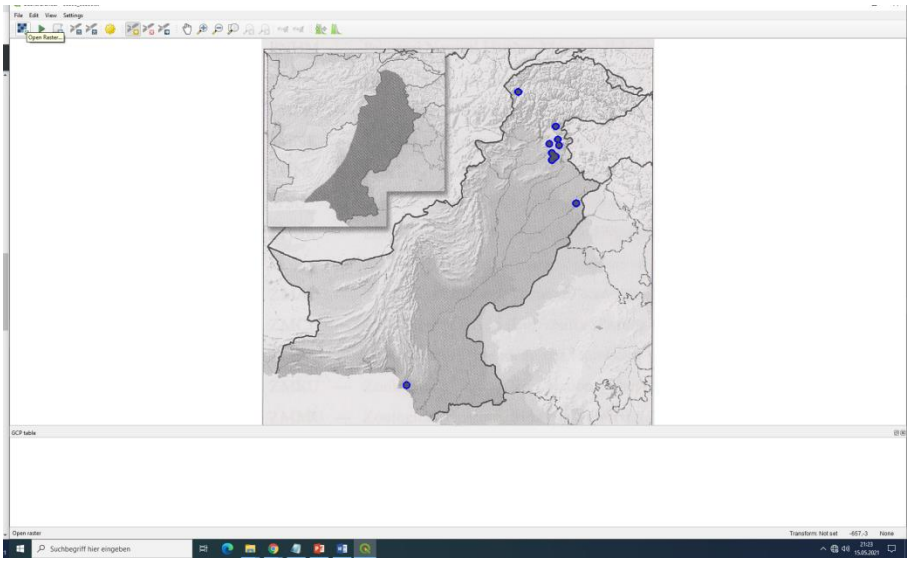
Step 2: Under plugins section on top of the page, select install plugins and install Georeferencer GDAL Package.



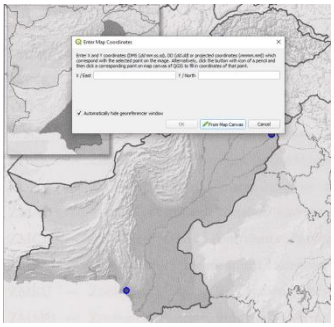
Step 3: After installing the Georeferencer module, select raster on top the screen panel and click on Georeferencer.



Step 4: Now, the Georeferencer window will open up and under this window, select the raster icon and load the output of pixel classification that has to be georeferenced.



Step 5: Select the points in the map, a pop-up-window called ‘Enter Map Coordinates’ will show up. Select the map canvas and mark the corresponding points in the OSM layer too.



All these points will be recorded in the GCP table. Do this for 50 GCP points. (**Hint:** If you choose the perfect matching maps from the output, you don’t have to mark these points each and every time). Finally, repeat this step for all the maps and Geo-referencing is completed.

Output of Geo-referencing:

The output of geo-referencing is similar to pixel classification output, but in this case, all the Cartesian coordinates will be replaced with geographical coordinates.

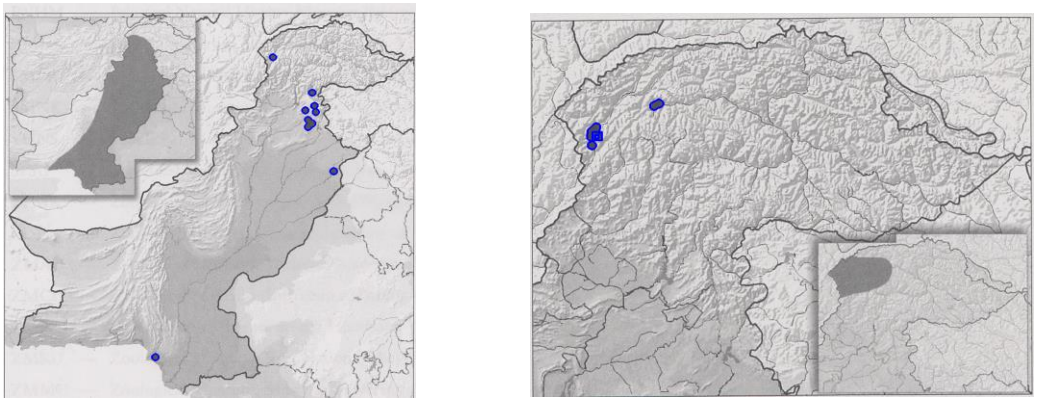


Fig 8: *Geo-referenced Maps.*

Tasks:

1) Install QGIS Software and load OSM (Open Street Map for the QGIS Software).
2) Geo-reference all the output files.

References:

E. Davies *Machine Vision: Theory, Algorithms and Practicalities*, Academic Press, 1990, pp 42 - 44.

R. Gonzalez and R. Woods *Digital Image Processing*, Addison-Wesley Publishing Company, 1992, p 191.

R. Haralick and L. Shapiro *Computer and Robot Vision*, Addison-Wesley Publishing Company, 1992, Vol. 1, Chap. 7.

B. Horn *Robot Vision*, MIT Press, 1986, Chap. 8.

D. Vernon *Machine Vision*, Prentice-Hall, 1991, pp 59 - 61, 214.