

Fixed Point Layers for Geodesic Morphological Operations: Supplementary Material

Santiago Velasco-Forero¹
santiago.velasco@minesparis.psl.eu

Ayoub Rhim²
ayoub.rhim@eleves.enpc.fr

Jesus Angulo¹
jesus.angulo@minesparis.psl.eu

¹ MINES Paris, PSL University
Center for Mathematical Morphology
Fontainebleau, France

² Ecole Nationale des Ponts et
Chaussées
Champs-sur-Marne, France

A Tensorflow Implementation

```
def condition_equal(last,new,image):
    return tf.math.logical_not(
        tf.reduce_all(tf.math.equal(last, new)
    ))
def update_dilation(last,new,mask):
    return [new, geodesic_dilation_step(
        ([new, mask]), mask)
def geodesic_dilation_step(X):
    return Minimum() ([MaxPooling2D(
        pool_size=(3, 3),strides=(1,1),
        padding='same') (X[0]),X[1]))
def geodesic_dilation(X,steps=None):
    rec = X[0]
    _,rec,_=tf.while_loop(condition_equal,
                          update_dilation,
                          [X[0], rec, X[1]],
                          maximum_iterations=steps)
    return rec
```

Figure 1: Geodesic Reconstruction implementation via `while_loop` function

B Complementary Examples

Another example of the prediction for the different models considered is given in Figure 2. The training curve for the CNN model and the proposed model CNN_R is presented for six repetitions of the experiment Figure 3. One can clearly notice that the inclusion of reconstruction facilitates convergence in fewer epochs and at a lower value.

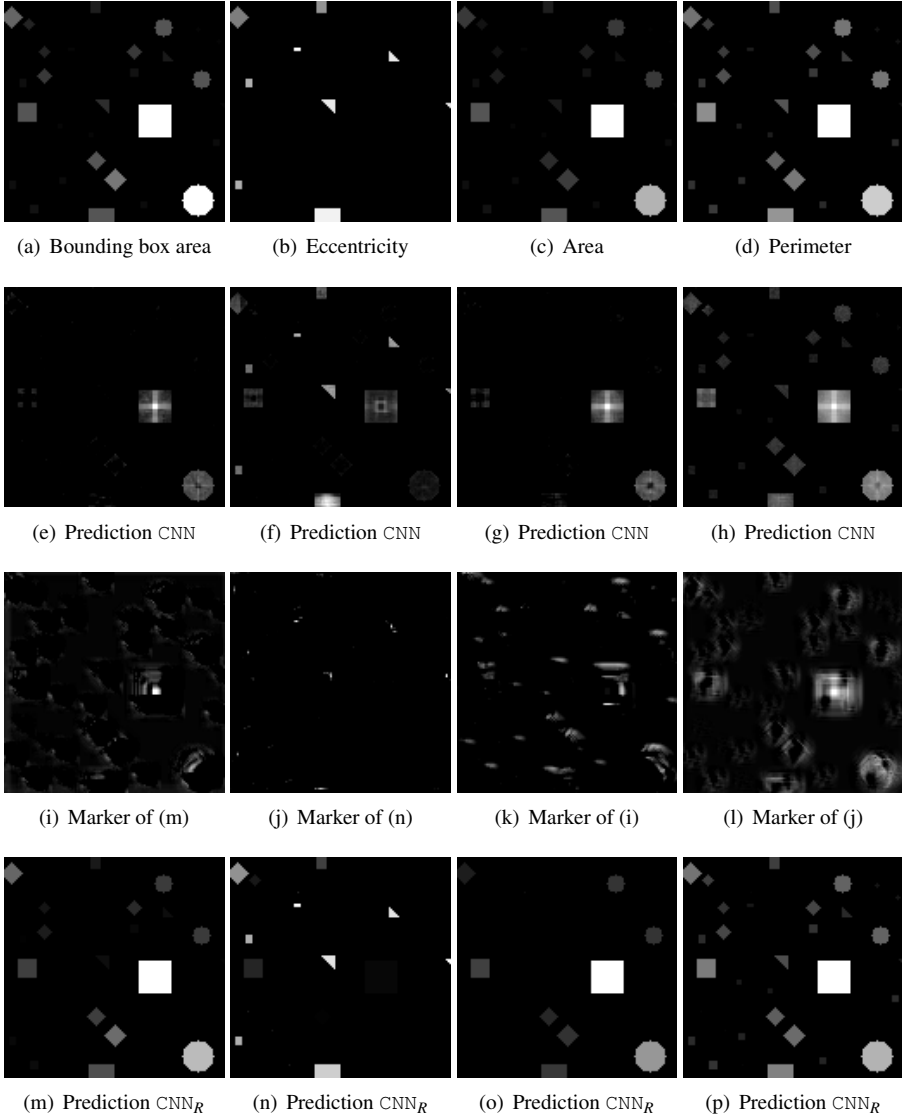


Figure 2: a) Example of a random image containing geometrical shapes as Circles, Squares, Triangles and Rectangles. b) Bounding box Area c) Eccentricity d) Area e) Perimeter. f) Example of prediction for the attribute perimeter e) for a CNN in f) and the proposed CNN_R in g). Both trained models in f) and g) have the same number of parameters. CNN_R homogenises the results of the CNN inside each object, drastically reducing the validation loss in Fig. 3

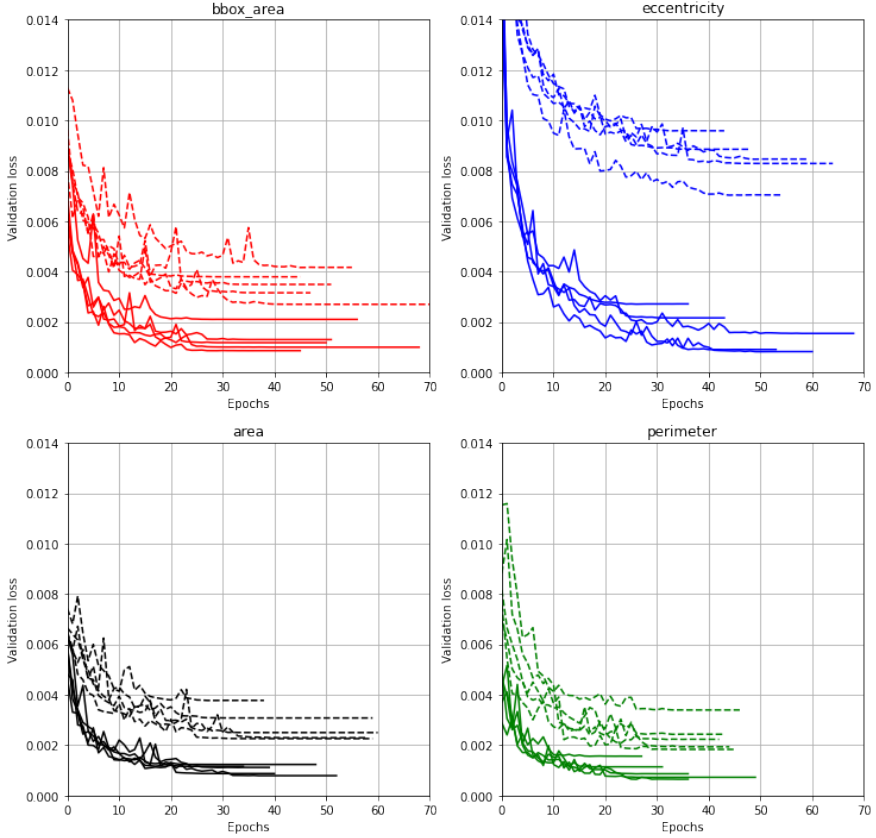


Figure 3: Several repetitions of the training protocol by varying the random initialisation. Dotted lines correspond to traditional CNN, and plain lines to CNN_R , i.e. with a reconstruction as the last layer. Note that CNN and CNN_R models have the same number of parameters. In the explored scenarios, the inclusion of the geodesic reconstruction helps to converge to a model with lower validation loss.