**Veterinary Thermographic Image Analysis**

**Comparison of efficacy for large and small masks in Thermographic Images of** **Chiari dogs for syrinx identification**

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# Comparing large masks and smaller masks for syrinx identification

**Primary finding:** small masks that do not include peripheral areas perform better than the larger masks in the differentiation of the classes *syrinx* and *no syrinx* in top of head images of dogs with Chiari malformation (CLMS/COMS).

Overview:

We considered total 93 images dividing into two classes; Syrinx = 48 and NoSyrinx = 45. The smaller masks were created by LIVS research coordinator Joe Sackman and the images were randomly picked. We considered the same images for large and the smaller masks in order to see which of them performs better. The reason to create a smaller mask rather than the initial (large) mask was that it does not include peripherals areas such as muzzle, ears, etc. The experiments included the following:

Classification Methods:

* K-Nearest Neighbor with K = 3
* Nearest Neighbor

Distance Metrics

* Euclidean Distance
* Normalized Vector Inner Product

Features

* Histogram features: Mean. Standard deviation, Skew, Energy and Entropy
* Texture features: Energy, Inertia, Correlation, Inverse difference, and Entropy. The texture distance of 6, 7, 8 and 9.

Data Normalization Method

* Soft-max with r = 1
* Standard Normal Density Normalization

Experiments for the 8,184 parameter combinations were performed. Results are tabulated for the best 10 results and statistics for all 8,184 experiments in the next two sections.

Here, the top 10 best results from each texture distance (6,7,8,9) are selected, and the averages and variances are calculated for those 10.

**Texture distance = 6; the 10 best results**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 63 | 66.67 | 68.75 |
|  | 63 | 66.67 | 68.75 |
|  | 61 | 57.78 | 72.92 |
|  | 61 | 60 | 70.83 |
|  | 61 | 60 | 70.83 |
|  | 61 | 64.44 | 66.67 |
|  | 61 | 64.44 | 66.67 |
|  | 61 | 66.67 | 64.58 |
|  | 61 | 68.89 | 62.5 |
|  | 61 | 68.89 | 62.5 |
| *average* | *61.4* | *64.445* | *67.5* |
| *std dev* | *0.843274043* | *3.920122589* | *3.568121199* |

|  |
| --- |
| **Small mask** |
|  |
| |  |  |  |  | | --- | --- | --- | --- | |  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** | |  | 65 | 57.78 | 81.25 | |  | 64 | 53.33 | 83.33 | |  | 64 | 68.89 | 68.75 | |  | 64 | 71.11 | 66.67 | |  | 64 | 73.33 | 64.58 | |  | 63 | 53.33 | 81.25 | |  | 63 | 60 | 75 | |  | 63 | 62.22 | 72.92 | |  | 63 | 64.44 | 70.83 | |  | 63 | 66.67 | 68.75 | | *average* | *63.6* | *63.11* | *73.333* | | *std dev* | *0.699205899* | *7.043272598* | *6.646056558* | |
| For this case, small masks are better because the average of total results are higher with small masks rather than large masks, and the best success rate for the syrinx class is better by over 10%. |

**Texture distance = 7; the 10 best results**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 71 | 75.56 | 77.08 |
|  | 65 | 71.11 | 68.75 |
|  | 63 | 71.11 | 64.58 |
|  | 63 | 73.33 | 62.5 |
|  | 62 | 68.89 | 64.58 |
|  | 61 | 60 | 70.83 |
|  | 61 | 64.44 | 66.67 |
|  | 60 | 51.11 | 77.08 |
|  | 60 | 57.78 | 70.83 |
|  | 60 | 57.78 | 70.83 |
| *average* | *62.6* | *65.111* | *69.373* |
| *std dev* | *3.373096171* | *8.117731552* | *5.011568949* |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 64 | 60 | 77.08 |
|  | 64 | 64.44 | 72.92 |
|  | 64 | 66.67 | 70.83 |
|  | 64 | 75.56 | 62.5 |
|  | 63 | 57.78 | 77.08 |
|  | 63 | 62.22 | 72.92 |
|  | 63 | 62.22 | 72.92 |
|  | 63 | 68.89 | 66.67 |
|  | 63 | 68.89 | 66.67 |
|  | 62 | 62.22 | 70.83 |
| *average* | *63.3* | *64.889* | *71.042* |
| *std dev* | *0.674948558* | *5.218244596* | *4.652119708* |

In this case the average values for the small masks are better except for the NoSyrinx class which is more only by about 0.2%. However, overall the #correct results indicate that the small masks work better.

**Texture distance = 8; the 10 best results**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 61 | 60 | 70.83 |
|  | 61 | 64.44 | 66.67 |
|  | 61 | 66.67 | 64.58 |
|  | 61 | 66.67 | 64.58 |
|  | 60 | 51.11 | 77.08 |
|  | 60 | 57.78 | 70.83 |
|  | 60 | 60 | 68.75 |
|  | 60 | 60 | 68.75 |
|  | 60 | 62.22 | 66.67 |
|  | 59 | 62.22 | 64.58 |
| *average* | *60.3* | *61.111* | *68.332* |
| *std dev* | *0.674948558* | *4.596683466* | *3.90318901* |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 64 | 73.33 | 64.58 |
|  | 63 | 62.22 | 72.92 |
|  | 63 | 66.67 | 68.75 |
|  | 63 | 71.11 | 64.58 |
|  | 62 | 57.78 | 75 |
|  | 62 | 60 | 72.92 |
|  | 62 | 62.22 | 70.83 |
|  | 62 | 62.22 | 70.83 |
|  | 62 | 64.44 | 68.75 |
|  | 62 | 64.44 | 68.75 |
| *average* | *62.5* | *64.443* | *69.791* |
| *std dev* | *0.707106781* | *4.79986354* | *3.438896625* |

Here the averages are higher for small masks and the variances (comparing small and large) are similar. Overall, the success rate from small masks has slightly better performance than the large masks.

**Texture distance = 9; the 10 best results**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 65 | 73.33 | 66.67 |
|  | 62 | 66.67 | 66.67 |
|  | 61 | 60 | 70.83 |
|  | 61 | 64.44 | 66.67 |
|  | 60 | 51.11 | 77.08 |
|  | 60 | 57.78 | 70.83 |
|  | 60 | 62.22 | 66.67 |
|  | 60 | 62.22 | 66.67 |
|  | 60 | 64.44 | 64.58 |
|  | 60 | 66.67 | 62.5 |
| *average* | *60.9* | *62.888* | *67.917* |
| *std dev* | *1.595131482* | *5.93020292* | *4.071393564* |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **# Correct (out of 93)** | **%Success NoSyrinx Class** | **%Success syrinx Class** |
|  | 64 | 64.44 | 72.92 |
|  | 64 | 68.89 | 68.75 |
|  | 63 | 62.22 | 72.92 |
|  | 63 | 62.22 | 72.92 |
|  | 63 | 64.44 | 70.83 |
|  | 63 | 66.67 | 68.75 |
|  | 63 | 66.67 | 68.75 |
|  | 63 | 73.33 | 62.5 |
|  | 62 | 60 | 72.92 |
|  | 62 | 60 | 72.92 |
| *average* | *63* | *64.888* | *70.418* |
| *std dev* | *0.666666667* | *4.164097341* | *3.374926501* |

In this case, the small mask averages are better than the large mask averages, and standard deviations are smaller. Taken together this indicates the small masks are better.

Here, we calculated the statistics, average and standard deviation, for all 8,184 permutations of various parameters (each permutation one experiment) to compare the results from both mask types with all four texture distances.

**Texture Distance = 6; statistics for all 8,184 experiments**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 44.87268 | 46.16405547 | 50.20597996 |
| std. deviation | 4.995432 | 7.989716933 | 7.163007577 |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 49.62793 | 49.13213954 | 57.3301063 |
| std. deviation | 5.130963 | 7.686609736 | 7.433693993 |

The average and the standard deviation for small mask is higher than the large mask.

**Texture Distance = 7; statistics for all 8,184 experiments**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 43.92399804 | 44.19868891 | 50.07201246 |
| std. deviation | 5.082729091 | 8.47017473 | 7.294041848 |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 48.62536657 | 47.16803152 | 57.08268084 |
| std. deviation | 4.699569715 | 7.166630303 | 7.152635099 |

The average for small mask is higher than the larger mask. For standard deviation, there is a small difference.

**Texture Distance = 8; statistics for all 8,184 experiments**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 43.47104106 | 44.38846041 | 48.95039467 |
| std. deviation | 4.865980195 | 7.782756489 | 7.1026793 |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 49.20026882 | 47.14095186 | 58.305815 |
| std. deviation | 4.593812279 | 7.080030163 | 7.016455975 |

The average values for small mask is better than the large mask and the variances are similar.

**Texture Distance = 9; statistics for all 8,184 experiments**

**Large mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 43.92302053 | 45.27063661 | 49.06501711 |
| std. deviation | 4.806375645 | 7.140818335 | 7.229278236 |

**Small mask**

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Overall out of 93** | **NO syrinx success %** | **Syrinx success %** |
| average | 48.67619746 | 47.52271139 | 56.85611193 |
| std. deviation | 4.666409607 | 6.968170579 | 7.049295129 |

The average values for small mask is better than the large mask, with similar variances.

**Conclusion**

The top 10 best results with texture distances of 6 and 9 indicates the small masks are better than the large masks. With texture distances of 7 and 8, the results are close but the small masks have slightly better results. Comparing the overall 8,184 experiments, the average results indicate the small masks are better than the large masks and the similar variances indicate the validity of the mean comparison.