**Summary:** I attempted to classify a 99-class leaf dataset using two different inputs to neural networks; raw image and sift features. When I used SIFT, I had to use the bag of words technique to utilize this information in a useful manner, this leads to an average accuracy of 0.72 and average F1 score of 0.7. When I fed the raw image (resized, flattened, and normalized) to the neural network I got much worse results with all the classes included, those results are shown below. I then completed this second method by reducing the number of classes used to produce somewhat acceptable results achieving an accuracy of 0.36 and average F1 score of 0.36.

**Dataset Description:** The leaf dataset consists of 990 black and white images. This is a multi-class dataset with 99 classes and 10 images per class.

**Normalizing Images:** Originally images were being fed to the Raw Image Classifier were resized to be 300 x 300 using the cv2 library. Later images were being resized by converting the jpeg to svg and then resizing to 300x300, and then converting back to jpeg. There was no need to grayscale this dataset because it was already black and white.

**Splitting the dataset:** I split the dataset into the test and train datasets using a 70:30 split.

**Compare sift classifier and raw image classifier:** The sift classifier performed way better than the raw image classifier in every case. Raw images that are not resized had horrific results, especially when all 99 classes were used – the results improved significantly when only 15 classes were used. When the resized images were used there was an additional boost to the performance for the Raw Image Classifier but no improvement for the SIFT classifier.

**Here is an example of what I can/cannot classify well and my explanation of why:**

**USING SIFT**

The loss curve is shown below.

A picture containing shape

Description automatically generated

The classification report is shown below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **class** | **precision** | **recall** | **f1-score** | **support** |
| 0 | 1.00 | 1 | 1 | 4 |
| 1 | 1.00 | 1 | 1 | 1 |
| 2 | 1.00 | 1 | 1 | 3 |
| 3 | 1.00 | 1 | 1 | 6 |
| 4 | 1.00 | 1 | 1 | 2 |
| 5 | 1.00 | 1 | 1 | 3 |
| 6 | 1.00 | 1 | 1 | 2 |
| 7 | 1.00 | 1 | 1 | 6 |
| 8 | 0.25 | 1 | 0.4 | 1 |
| 9 | 1.00 | 1 | 1 | 2 |
| 10 | 1.00 | 0.75 | 0.86 | 4 |
| 11 | 1.00 | 1 | 1 | 4 |
| 12 | 0.67 | 1 | 0.8 | 2 |
| 13 | 1.00 | 1 | 1 | 2 |
| 14 | 1.00 | 1 | 1 | 4 |
| 15 | 1.00 | 1 | 1 | 1 |
| 17 | 1.00 | 0.67 | 0.8 | 3 |
| 18 | 0.00 | 0 | 0 | 3 |
| 19 | 1.00 | 1 | 1 | 5 |
| 20 | 0.67 | 0.67 | 0.67 | 3 |
| 21 | 1.00 | 1 | 1 | 1 |
| 22 | 0.25 | 0.67 | 0.36 | 3 |
| 23 | 1.00 | 0.5 | 0.67 | 4 |
| 24 | 0.50 | 1 | 0.67 | 1 |
| 25 | 1.00 | 1 | 1 | 3 |
| 26 | 1.00 | 0.5 | 0.67 | 2 |
| 27 | 0.67 | 0.4 | 0.5 | 5 |
| 28 | 0.50 | 1 | 0.67 | 1 |
| 29 | 0.20 | 0.33 | 0.25 | 3 |
| 30 | 0.00 | 0 | 0 | 3 |
| 31 | 0.50 | 1 | 0.67 | 2 |
| 32 | 0.50 | 0.67 | 0.57 | 3 |
| 33 | 1.00 | 0.8 | 0.89 | 5 |
| 34 | 1.00 | 0.4 | 0.57 | 5 |
| 35 | 1.00 | 0.67 | 0.8 | 3 |
| 36 | 0.00 | 0 | 0 | 0 |
| 37 | 0.33 | 1 | 0.5 | 1 |
| 38 | 0.00 | 0 | 0 | 3 |
| 39 | 0.40 | 0.67 | 0.5 | 3 |
| 40 | 0.00 | 0 | 0 | 1 |
| 41 | 0.67 | 1 | 0.8 | 4 |
| 42 | 1.00 | 1 | 1 | 3 |
| 43 | 0.67 | 1 | 0.8 | 2 |
| 44 | 0.00 | 0 | 0 | 0 |
| 45 | 1.00 | 1 | 1 | 3 |
| 46 | 1.00 | 1 | 1 | 1 |
| 47 | 1.00 | 1 | 1 | 3 |
| 48 | 1.00 | 0.43 | 0.6 | 7 |
| 49 | 1.00 | 1 | 1 | 3 |
| 50 | 1.00 | 0.75 | 0.86 | 4 |
| 51 | 1.00 | 1 | 1 | 1 |
| 52 | 1.00 | 0.67 | 0.8 | 3 |
| 53 | 0.40 | 0.67 | 0.5 | 3 |
| 54 | 0.33 | 1 | 0.5 | 1 |
| 55 | 0.17 | 1 | 0.29 | 1 |
| 56 | 0.57 | 1 | 0.73 | 4 |
| 57 | 0.33 | 0.5 | 0.4 | 2 |
| 58 | 1.00 | 0.67 | 0.8 | 3 |
| 59 | 0.00 | 0 | 0 | 2 |
| 60 | 0.00 | 0 | 0 | 1 |
| 61 | 0.40 | 1 | 0.57 | 2 |
| 62 | 1.00 | 1 | 1 | 3 |
| 63 | 0.33 | 0.5 | 0.4 | 2 |
| 64 | 0.80 | 0.8 | 0.8 | 5 |
| 65 | 0.75 | 0.75 | 0.75 | 4 |
| 66 | 1.00 | 0.5 | 0.67 | 2 |
| 67 | 0.00 | 0 | 0 | 4 |
| 68 | 1.00 | 0.8 | 0.89 | 5 |
| 69 | 0.67 | 0.67 | 0.67 | 3 |
| 70 | 0.75 | 0.6 | 0.67 | 5 |
| 71 | 1.00 | 1 | 1 | 2 |
| 72 | 1.00 | 0.17 | 0.29 | 6 |
| 73 | 0.43 | 1 | 0.6 | 3 |
| 74 | 1.00 | 1 | 1 | 1 |
| 75 | 1.00 | 1 | 1 | 4 |
| 76 | 1.00 | 1 | 1 | 2 |
| 77 | 0.67 | 0.57 | 0.62 | 7 |
| 78 | 1.00 | 1 | 1 | 3 |
| 79 | 1.00 | 1 | 1 | 3 |
| 80 | 0.80 | 1 | 0.89 | 4 |
| 81 | 0.00 | 0 | 0 | 3 |
| 82 | 0.50 | 0.67 | 0.57 | 3 |
| 83 | 0.50 | 1 | 0.67 | 1 |
| 84 | 0.00 | 0 | 0 | 0 |
| 85 | 1.00 | 1 | 1 | 5 |
| 86 | 0.00 | 0 | 0 | 4 |
| 87 | 0.50 | 0.25 | 0.33 | 4 |
| 88 | 0.33 | 1 | 0.5 | 2 |
| 89 | 0.67 | 1 | 0.8 | 2 |
| 90 | 0.50 | 0.5 | 0.5 | 6 |
| 91 | 1.00 | 0.2 | 0.33 | 5 |
| 92 | 1.00 | 1 | 1 | 3 |
| 93 | 0.67 | 1 | 0.8 | 2 |
| 94 | 0.75 | 1 | 0.86 | 3 |
| 95 | 1.00 | 1 | 1 | 5 |
| 96 | 0.33 | 0.33 | 0.33 | 3 |
| 97 | 1.00 | 0.57 | 0.73 | 7 |
| 98 | 1.00 | 1 | 1 | 5 |
|  |  |  |  |  |
| accuracy |  |  | 0.72 | 297 |
| macro | avg | 0.69 | 0.73 | 0.67 |
| avg | 0.76 | 0.72 | 0.7 | 297 |

**USING RAW IMAGE**

The loss curve is shown below.

Shape

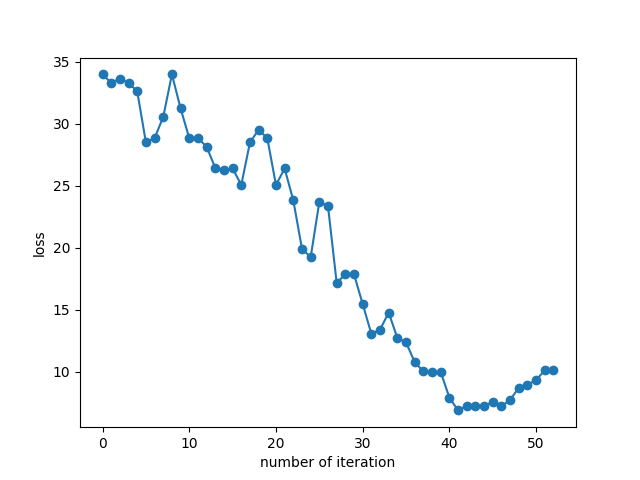
Description automatically generated

The classification report is shown below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **class** | **precision** | **Recall** | **f1-score** | **support** |
| 0 | 0 | 0 | 0 | 6 |
| 1 | 0 | 0 | 0 | 3 |
| 2 | 0 | 0 | 0 | 4 |
| 3 | 0 | 0 | 0 | 3 |
| 5 | 0 | 0 | 0 | 1 |
| 6 | 0 | 0 | 0 | 1 |
| 7 | 0 | 0 | 0 | 3 |
| 8 | 0 | 0 | 0 | 3 |
| 9 | 0 | 0 | 0 | 2 |
| 10 | 0 | 0 | 0 | 5 |
| 11 | 0 | 0 | 0 | 0 |
| 12 | 0 | 0 | 0 | 1 |
| 13 | 0 | 0 | 0 | 4 |
| 14 | 0 | 0 | 0 | 3 |
| 15 | 0 | 0 | 0 | 2 |
| 16 | 0 | 0 | 0 | 2 |
| 17 | 0 | 0 | 0 | 2 |
| 18 | 0 | 0 | 0 | 4 |
| 20 | 0.14 | 1 | 0.25 | 1 |
| 21 | 0 | 0 | 0 | 2 |
| 22 | 0 | 0 | 0 | 2 |
| 23 | 0 | 0 | 0 | 1 |
| 24 | 0 | 0 | 0 | 2 |
| 25 | 0 | 0 | 0 | 3 |
| 26 | 0 | 0 | 0 | 3 |
| 27 | 0 | 0 | 0 | 0 |
| 28 | 0 | 0 | 0 | 5 |
| 29 | 0 | 0 | 0 | 2 |
| 30 | 0 | 0 | 0 | 2 |
| 31 | 0.05 | 1 | 0.09 | 1 |
| 32 | 0 | 0 | 0 | 1 |
| 33 | 0 | 0 | 0 | 3 |
| 34 | 0 | 0 | 0 | 3 |
| 35 | 0 | 0 | 0 | 1 |
| 36 | 0 | 0 | 0 | 3 |
| 37 | 0 | 0 | 0 | 4 |
| 38 | 0 | 0 | 0 | 2 |
| 39 | 0 | 0 | 0 | 3 |
| 40 | 0 | 0 | 0 | 3 |
| 41 | 0 | 0 | 0 | 2 |
| 42 | 0 | 0 | 0 | 7 |
| 43 | 0 | 0 | 0 | 3 |
| 44 | 0 | 0 | 0 | 5 |
| 45 | 0 | 0 | 0 | 3 |
| 46 | 0 | 0 | 0 | 3 |
| 47 | 0 | 0 | 0 | 5 |
| 48 | 0 | 0 | 0 | 3 |
| 49 | 0 | 0 | 0 | 3 |
| 50 | 0 | 0 | 0 | 3 |
| 51 | 0 | 0 | 0 | 3 |
| 52 | 0 | 0 | 0 | 3 |
| 53 | 0 | 0 | 0 | 6 |
| 54 | 0 | 0 | 0 | 2 |
| 55 | 0 | 0 | 0 | 4 |
| 56 | 0 | 0 | 0 | 1 |
| 57 | 0 | 0 | 0 | 3 |
| 58 | 0 | 0 | 0 | 1 |
| 59 | 0 | 0 | 0 | 1 |
| 60 | 0 | 0 | 0 | 7 |
| 61 | 0 | 0 | 0 | 5 |
| 62 | 0.03 | 1 | 0.07 | 1 |
| 63 | 0 | 0 | 0 | 2 |
| 64 | 0 | 0 | 0 | 4 |
| 65 | 0 | 0 | 0 | 2 |
| 66 | 0 | 0 | 0 | 3 |
| 67 | 0 | 0 | 0 | 2 |
| 68 | 0 | 0 | 0 | 4 |
| 69 | 0 | 0 | 0 | 1 |
| 70 | 0 | 0 | 0 | 4 |
| 71 | 0 | 0 | 0 | 3 |
| 72 | 0 | 0 | 0 | 3 |
| 73 | 0 | 0 | 0 | 1 |
| 74 | 0 | 0 | 0 | 2 |
| 75 | 0 | 0 | 0 | 4 |
| 76 | 0 | 0 | 0 | 1 |
| 77 | 0 | 0 | 0 | 3 |
| 78 | 0 | 0 | 0 | 3 |
| 79 | 0 | 0 | 0 | 6 |
| 80 | 0 | 0 | 0 | 4 |
| 81 | 0 | 0 | 0 | 3 |
| 82 | 0 | 0 | 0 | 2 |
| 83 | 0 | 0 | 0 | 3 |
| 84 | 0 | 0 | 0 | 4 |
| 85 | 0 | 0 | 0 | 5 |
| 86 | 0 | 0 | 0 | 4 |
| 87 | 0 | 0 | 0 | 3 |
| 88 | 0 | 0 | 0 | 3 |
| 89 | 0 | 0 | 0 | 2 |
| 90 | 0 | 0 | 0 | 4 |
| 91 | 0 | 0 | 0 | 4 |
| 92 | 0 | 0 | 0 | 7 |
| 93 | 0 | 0 | 0 | 5 |
| 94 | 0 | 0 | 0 | 5 |
| 95 | 0 | 0 | 0 | 5 |
| 96 | 0 | 0 | 0 | 6 |
| 97 | 0 | 0 | 0 | 5 |
| 98 | 0 | 0 | 0 | 5 |
|  |  |  |  |  |
| accuracy |  |  | 0.01 | 297 |
| macro avg | 0 | 0.03 | 0 | 297 |
| weighted avg | 0 | 0.01 | 0 | 297 |

**USING RAW IMAGE WITH A REDUCED NUMBER OF CLASSES**

The loss curve is shown below.



The classification report is shown below.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **class** | **precision** | **recall** | **f1-score** | **support** |
|  |  |  |  |  |
| 1 | 0.5 | 0.25 | 0.33 | 4 |
| 2 | 1 | 0.6 | 0.75 | 5 |
| 3 | 0.8 | 1 | 0.89 | 4 |
| 4 | 0 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 | 2 |
| 6 | 0 | 0 | 0 | 2 |
| 7 | 0 | 0 | 0 | 3 |
| 8 | 0.33 | 0.67 | 0.44 | 3 |
| 9 | 0.33 | 0.25 | 0.29 | 4 |
| 10 | 0.5 | 0.6 | 0.55 | 5 |
| 11 | 0 | 0 | 0 | 1 |
| 12 | 0 | 0 | 0 | 2 |
| 13 | 0.2 | 0.25 | 0.22 | 4 |
| 14 | 0 | 0 | 0 | 4 |
| 15 | 1 | 0.5 | 0.67 | 2 |
|  |  |  |  |  |
| accuracy |  |  | 0.36 | 45 |
| macro avg | 0.31 | 0.27 | 0.28 | 45 |
| weighted avg | 0.4 | 0.36 | 0.36 | 45 |