L05 Image Classification with SVM

Martin Demel

Department of Science, Technology, Engineering & Math, Houston Community College

ITAI-1378: Computer Vision Artificial Intelligence

Patricia McManus

September 29th, 2024

**Introduction**

This assignment is very interesting to me as I have not worked with the SVM before. Throughout the journal you will understand the steps I have taken; how do I approach learning new skills and challenges I have faced during this laboratory work. A couple of Aha moments that were very important during my learning path. Overall, I have really enjoyed the assignment as it thought me new ways of analyzing large datasets. I felt really energized and motivated to learn deeper about how the images are processed in large datasets.

**Understanding the SVM, CIFAR-10 and Scikit-Learn**

Initially, I have identified key terminologies that I was not very familiar with including SVM, CIFAR-10 and Scikit-Learn.

When I found reputable source on IBM.com [1] explaining how the SVMs works I felt little confused and perhaps not understanding the topic clearly. “I asked ChatGPT to explain SVM in simpler terms, which helped clarify some of the more complex concepts (OpenAI, personal communication, September 26, 2024).”

The explanation was adequate, but I was still missing some details and perhaps I was missing visual explanation. I found the geeksforgeeks article [3] that ultimately helped me to understand how SVMs really works. This was one of the *Aha* moments when I fully understand the topic and was comfortable to proceed further in my lab work.

A diagram of a graph

Description automatically generated with medium confidenceIn simple words a SVM draw a boundary line between the datapoints that are different, this line called hyperplane. There are multiple lines drawn to segregate the datapoints which comes to second part to select the best hyperplane with the best margin. SVM can also effectively handle outliers. It will adjust the margin and will ignore the point that don’t fit well with the rest of the data.

Figure 1 – Demonstration of Hyperplane [3]

Portrayed in Figure 1 – Demonstration of Hyperplane. [3]

Secondly, it was important for me to understand the difference between linear and nonlinear SVMs. In simple words, much of the real-world data is non-linearly separable, so it is typically processed by nonlinear SVMs. This is achieved by transforming the data using the **kernel trick**, allowing the SVM to classify data that is not linearly separable. When it comes to CIFAR-10, I have learned that it’s the dataset of 60 000 images divided into 10 classes [4]. At first, I was unsure how the data can be used and what use cases can be applied. Quickly have I learned that there are broad applications possibilities such as, security camera detection, especially for dogs and cat’s category. Image search in my phone is another great category. So, solving real life problems or developing application that will have element of identification / classification with the CIFAR-10 dataset can be very beneficial.

This was another *Aha* moment for me when I realized that the data, tools, frameworks, systems, are available--you just need to have a great idea to create great things.

Scikit-Learn library was easy to understand as I am familiar with NumPy and SciPy. I was particularly interested what is the difference between these NumPy, SciPy compared to Scikit-Learn. I have quickly learned that Scikit-Learn is focused primarily on

Machine learning and its practically build on top of NumPy and SciPy. Now I know that for my future project where classification, regression or model training will be required I can use Scikit-Learn.

At this point I feel confident enough to perform the actual laboratory work and get a hands-on experience.

**Laboratory work**

After downloading and loading the laboratory Jupyter file I Have realized that the laboratory work is completed with explanation. At this point I have decided to take slightly different route and to build my own laboratory file from scratch.

Based on my personal learning experience, I find that the best way for me to develop and learn new skills is by creating / performing the tasks myself. Hands-on experience helps me understand the concepts better and build the necessary skills.

Once I have completed the installation of the missing library scikit-learn I have initiated import of the rest of the libraries. I have crosschecked that all the necessary libraries were imported against the laboratory file provided.

From my earlier learning experience about the CIFAR-10 dataset I already knew how to load the data which I did. I have decided to include all 10 classes as I wanted to try the computation power of my MacBook Pro during the training the model. In total it took only 14 minutes to perform all the tasks.

Moving next, I converted the images to grayscale and fatten them. I have achieved that by writing the code in Cursor. The reason I selected cursor to write this part of the code is its simple collaboration with AI on the actual code and injecting specific code parts.

Another *Aha* moment I had was when I learned from the document provided for the lab that the RGB weights values that are commonly used for the RGB image to grayscale are R 0.2989, G 0.5870 and B 0.1140 respectively. From the coding perspective I tried to use the following but unsuccessfully: gray\_img = cv2.cvtColor(img, cv2.COLOR\_RGB2GRAY).

To normalize and flatten the images, I had to convert them from 2D to 1D. To do that I had to change the range of the pixel values so called normalization. I have learned that during the search with cursor on how to pre-process the data. Furthermore, we had to split the data into training and validations sets.

Once we have preprocessed the data it was time to do model training. This is where the SVM comes into play and was trained on preprocessed data. I have used the linear kernel to classify the images without any fine-tuning. I was aware that real-world scenarios like the CIFAR-10 dataset is non-linear dataset and different kernel like RBF should be used instead. I will perhaps try the RBF kernel with the cloud computation power as the RBF kernel will be more time demanding.

Following the selection of the kernel it was time to make predictions on the test data, this was achieved by inserting the code: *y\_pred = svm\_model.predict(X\_test\_scaled)*

Next step was to evaluate the performance by using accuracy.

To evaluate the performance of the SVM model, I calculated the accuracy score by using accuracy\_score function from the scikit-learn. By this I have learned the exact accuracy score was 28,13% only.

A blurry image of a deer

Description automatically generatedI was a little skeptical at first, but also very eager to understand what went possibly wrong or what needs to be improved. This is something I enjoy very much, being problem solver. I have learned that CIFAR-10 dataset is very complex and using basic liner kernel is perhaps not the best solution. I have also covered this topic in the “Understanding the SVM, CIFAR-10 and Scikit-Learn” part of this laboratory assignment. AS I have pointed out most of the real-world data is nonlinear. For this type of the laboratory work RBF would be a better choice.

To further analyze the outcome, I focused on visualizing the predictions and with the true label. I was unsure how to perform this task and I have used the code provided from the provided notebook. I have found the notebook very important and helpful throughout the entire assignment, especially the coding part helped me. This was the first time I have seen what the SVM was working with.

Figure 2 – Image from top Original, grayed and normalized.

From the quality and the type of the images (Figure 2 - original, grayed and normalized) I further confirmed my original hypothesis that the liner kernel selection is not optimal. At least to what I have learned. In other words, it helped me to understand where the model did more accurate classification.

**Conclusion**

This laboratory work was a great experience in expanding my knowledge of machine learning and image classification using SVM. Initially I was unfamiliar, but I have quickly learned by exploring and researching different topics. By doing so, I feel more comfortable now using the algorithm and its application in real world scenarios. I especially appreciate myself for building the lab from scratch which helped me understand the SVM deeper. But without provided laboratory files it would take me much longer to perform the actual tasks.

I am excited to continue to further develop my skillset with using SVM by performing more demanding tasks in cloud environment using RBF and other fine-tuning techniques. I feel confident that I can apply basic SVM in real world now. I am now exited to learn about CNNs that I have learned in History of Artificial intelligence.

This assignment also strengthened my work-related skills that I can now apply in my job, specifically knowing how to analyze large image datasets with the Scikit-Learn library.

Throughout the assignment I have not only gained new skills but also learned how the image processing works in real life and knowing that I can build something myself that is used in our daily lives makes me feel pleased.

**Resources:**

[1] IBM. (2024, August 13). Support Vector Machine. IBM. <https://www.ibm.com/topics/support-vector-machine>

[2] OpenAI. ChatGPT. Accessed September 26, 2024. <https://chat.openai.com>

[3] GeeksforGeeks. (2024, July 4). Support Vector Machine (SVM) algorithm. GeeksforGeeks. <https://www.geeksforgeeks.org/support-vector-machine-algorithm/>

[4] CIFAR-10 and CIFAR-100 datasets. (n.d.). <https://www.cs.toronto.edu/~kriz/cifar.html>