ECON 607 Assignment 4

Andrew Girgis

October 2023

Contents

List of Figures

1 Neural Networks and Machine Learning

1.1 What is Machine Learning?

Machine Learning is a branch of Artificial Intelligence (AI) that uses data and computer algorithms to mimic human learning gradually improving accuracy. Machine Learning is an important part of data science. Through the use of statistical methods, algorithms are trained to make classifications or predictions, and to uncover key insights in data projects ("What is machine learning?", n.d.). There are three main branches of machine learning;

1. Supervised Learning
2. Unsupervised Learning
3. Reinforcement Learning

1.1.1 Supervised Learning

Lets start by talking about supervised learning. Supervised learning is a method of machine learning in which the algorithm is given past labeled data with outputs, the algorithm then learns the input output pairs to shift the model to create outputs as accurate as possible.

1.1.2 Unsupervised Learning

Next is unsupervised learning. While with supervised learning you are providing the algorithm with a labeled data set, unsupervised learning does not use a labeled data set but instead looks for less obvious patterns within the data.

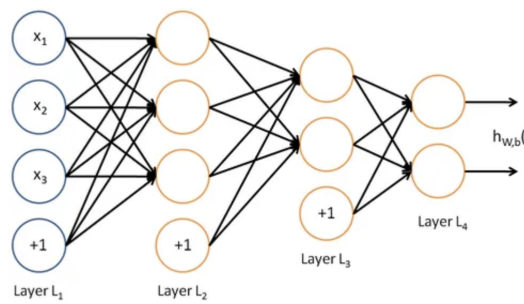
1.1.3 Reinforcement Learning

Finally there is reinforcement learning. Reinforcement learning algorithm learns by interacting with its environment and getting a positive or negative reward. Common algorithms include temporal difference, deep adversarial networks, and Q-learning ("3 Types of Machine Learning You Should Know", n.d.).

1.2 What are Neural Networks?

Neural networks are a subset of Machine learning. They are inspired by the way human brain neurons signal to one another. Neural networks or artificial neural networks (ANNs) are comprised of a node layers, containing an input layer, one or more hidden layers, and an output layer ("What are neural networks?", n.d.). See Figure 1 for a visual depiction of the layers in a neural network.

Figure 1: Visual representation of a neural network



In figure 1the first layer is the layer in which inputs are entered. There are 2 internals layers which are also called hidden layers, and one last layer that contains all the possible outputs(Arnx, 2019). Neural networks use training data to learn and improve their model and output accuracy over time. Each node acts as its own linear regression model with input data, weights, a bias, and an output. The formula looks something like this:

$$\sum w_i x_i + bias = w_1 x_1 + w_2 x_2 + ... + w_n x_n + bias \tag{1}$$

Where the output is:

$$f(x) = 1 \text{ if } \sum w_1 x_1 + bias \geq 0; \, 0 \text{ if } \sum w_1 x_1 + bias < 0$$

One thing to notice about this equation is that the output is binary 0 or 1. This output informs us what decision to make. For example if we are trying to make a decision whether to go out(1) or to stay in and study(0) we would give an input of some variables x:

1. x_1: Is there homework to do? (Yes:0, No:1)
2. x_2: Are friends going out? (Yes:1, No:0)
3. x_3: Will it cost over $40 (Yes:0, No:1)

With some weights to determine the importance of each variable.

1. w_1: 7, since it is very important to make sure you dont have outstanding homework before going out.
2. w_2: 4, since friends going out aswell makes it more appealing to go out.
3. w_3: 2, since the cost of going out is an important detail however it wont make or break a night out.

Then we assign a bias to the equation. This is the threshold for whether we go out or not, if the number given by the formula is greater than or equal to the bias then we will go out and if the number given by the formula is less than the threshold we will stay in. Lets assume a bias of -5 and lets say we have a scenario where;

1. $x_1 = 0$ since we have homework to do
2. $x_2 = 1$ since our friends are going out
3. $x_3 = 0$ since the plan is to go to a pricey restaurant and get drinks

In this case we have the equation:

$$\hat{Y} = (0 \cdot 7) + (1 \cdot 4) + (0 \cdot 2) - 5 = 4 - 5 = -1$$

Therefore since the formula gives us a number that is less than 0 we say the output is 0 thus based on these weights and circumstances the decision is to stay home and study. This is a simple example of how a neural network makes decisions.

1.3 3457th image in the test dataset

In this assignment we are using supervised learning machine learning algorithm to train the model to classify the articles of clothing. We do this by first providing it with a labeled training data set to learn from. We then set up the layers of the neural network using keras in the Tensorflow library. After we set up the layers we then compile and train the model using the training dataset. Finally, we evaluate the model to see how accurately the model performs on the test dataset. Since python is a 0 based index language, which means the arrays start counting from 0, to look for the first item we will output the 0th item in our predictions model. Therefore to look for the 3457th image in the dataset I used the code seen in figure 2 then input the number 3456 to find the prediction of the 3457th image.

Figure 2: Code used for prediction and output

```
predictions_Q1 = model.predict(test_images)
print(predictions_Q1[3456])
image_index = np.argmax(predictions[3456])
print("Predicted:", image_index, "Actual:", test_labels[3456])
print(class_names[image_index])
```

```
✓ 0.3s
```

```
313/313 [==============================] - 0s 729us/step
[8.8619655e-03 6.9699837e-03 7.5666362e-01 1.8509148e-02 2.3624878e-02
 1.2265837e-03 1.5748230e-01 8.1155309e-07 2.6657568e-02 3.1915442e-06]
Predicted: 2 Actual: 2
Pullover
```

As we can see in the output of the code in figure 2 the predicted is equal to the actual which tells us that the prediction is correct. To confirm this I plot the figure of the 3457th image(seen in figure 3) to confirm it matches with the labeled dataset(seen in figure 4). Since the image produced from plotting image 3457 and the image linked to pullover in the training dataset are the same article of clothing, I can confidently say that the prediction made by the machine learning algorithm is correct.

Figure 3: 3457th image in the test dataset

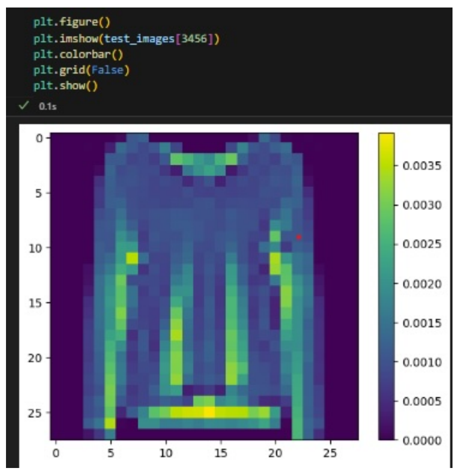


Figure 4: Labeled training dataset

2 Impact of COVID on circular fashion

2.1 Considering the circular economy for second-hand clothing, how did the COVID-19 pandemic impact Canadian exports?

The COVID-19 pandemic had a significant impact on the global economy, including the trade of clothing in Canada. The value of Canadian merchandise exports decreased close to 34% between February and April 2020 (Scarffe, 2022). After this decrease in merchandise exports, Canada recovered half of their value by June 2020 and were above 2019 average levels by January 2021. As seen in figure 5, since 2009 Canadian merchandise exports were on a steady incline until 2019 where we see a steep decrease in the dollars of Canadian merchandise goods exported until 2020 where we then see a very steep increase from 2021 to 2022. Based on this graph we can see that the pandemic had a strong initial decrease in Canadian merchandise exports where exports in dollars decreases from approximately 600 billion dollars to 525 billion dollars. However 2 years after the pandemic started in mid 2020 Canadian merchandise exports made a strong recovery increasing from 525 billion dollars to 775 billion dollars from 2020 to 2022. The sharp decrease in exports due to the pandemic would have had a negative impact on the circular economy for second-hand clothing since the clothing production factories slowed down due to closures and lack of workers once the pandemic started. Along with this, circular economy store closures also played a negative role in promoting circular fashion. Based on Salvation Army's Consolidated Financial statements for the years 2019-2020 "A significant decline was experienced by capital markets in March 2020 as a result to the COVID-19 pandemic; however, as of mid July 2020 as this report was being finalized, the Army's investments have fully recovered from the losses"("Consolidated Financial Statements Year ended March 2021", 2021) and in the Salvation Army's Consolidated Financial statements for the years 2020-2021 "[...] a reduction in sales of donated goods from 161 million last year to 107 million this year, as a result of store closures during the COVID-19 pandemic"("Consolidated Financial Statements Year Ended March 31, 2022", 2022). Therefore, overall the COVID-19 pandemic negatively impacted Canadian exports between the years 2019 and 2020, however merchandise exports made a strong recovery in the following years. The store closures and lack of donated goods as a result of COVID-19 had a strong negative impact on the economy of second hand clothing from 2019 till 2021 which has now, as of 2023 recovered "The largest increase was in sale of donated goods, which increased by 17.0%: sales rebounded in fiscal 2023 after several years of negative impacts from the pandemic..." ("CONSOLIDATED FINANCIAL STATEMENTS Year Ended March 31, 2023", 2023).

Figure 5: Line chart of Canadian merchandise exports (Statistics Canada, 2023a)

2.2 How did the pandemic impact domestic demand for pre-loved textiles in Canada?

The COVID-19 pandemic had various impacts on the domestic demand for pre-loved textiles. On March 17th 2020, Canada ordered a state of emergency and held a temporary lockdown for non essential businesses including retail and thrift stores. This meant during the time of the temporary lockdown individuals were urged to stay home and since stores were closed household weren't shopping as much as prior to the pandemic. A side effect of this was that households were donating less clothes since individuals couldnt shop at the retail stores to purchase new clothes then donate their old clothes. As we can see in the line chart in figure 6, there was a sharp decrease in household consumption of clothing and footwear in Q2 of 2020 which is exactly when Canada announced the temporary lockdown. After the lockdown was lifted we can see a increase in household consumption of clothing and footwear as it slowly grows back to follow the trend from pre-pandemic. This decrease in consumption due to the pandemic impacts domestic demand for second hand clothing negatively as not only are individuals not donating as much while the thift stores are closed, there was also a strong increase in online options and a large increase in online consumption over the COVID-19 pandemic. As we can see from the figure 7 provided by (Zanzana & Martin, 2023) many households made the switch to online shopping during the pandemic around April of 2020 and ended up continuing to use online shopping even after the lockdown ended as we can see from the e-commerce line in the graph still continues to trend upwards until

July 2022. Therefore the COVID-19 pandemic overall had a negative impact on the domestic demand for pre-loved textiles in Canada and as we can see that household consumption ended up recovering back to the original trend through a W shaped recovery, this recovery could be explained by the increase in e-commerce sales.

Figure 6: Line chart of Canadian household consumption on clothing and footwear (Statistics Canada, 2023b)

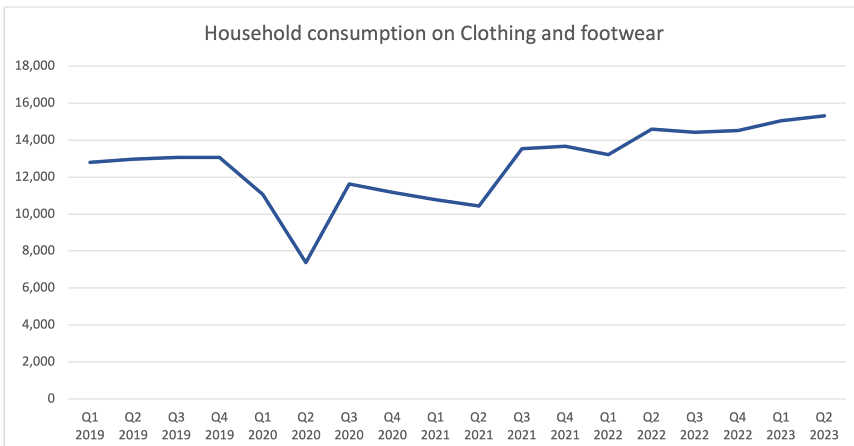
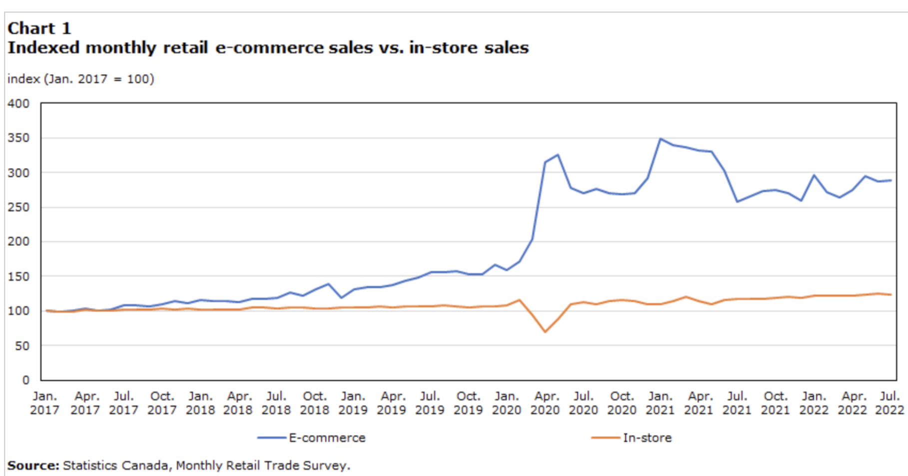


Figure 7: Monthly e-commerce sales vs in-store



2.3 How can machine learning help clothing brands reduce excess inventory resulting from their in-store buy-back programs?

By incorporating machine learning into their operations, clothing brands can better manage excess inventory generated by buy-back and resale programs. Some ways that machine learning can assist in mitigating the excess inventory problem is through personalized recommendations, quality control and marketplace insights.

Firstly, one area where machine learning is already being widely used is in marketing as it allows marketers to improve their decision-making by analyzing large data sets and generating insights about the industry, market, societal trends, and customer profiles. (Ahramovich, n.d.). Some big companies that are already making use of machine learning algorithms to optimize their business include Netflix using machine learning to personalize its content recommendations, Amazon using machine learning to suggest specific products to customers, and Spotify using machine learning to curate personalized playlists for users. On the same note clothing brands can use machine learning algorithms to analyze datasets of users behaviours when shopping to optimize personal recommendations for the user. For example if they notice that in September as fall is close, more consumers are shopping for sweaters and jackets then they can use machine learning to recommend personal recommendations of sweaters similar to the clothing the user has viewed or bought beforehand. If the individual purchased or viewed many graphic tees in the past it is likely the same user would shop for a graphic sweater for the fall.

Secondly, as demonstrated in the exercise performed in Section 1.3 machine learning algorithms are capable of being given visual data with labels to learn how to classify articles of clothing, a similar algorithm can be applied for quality control of the clothing. Instead of having current employees or needing to hire new employees to sort clothing that are in good condition versus the clothing that aren't in good condition machine learning algorithms can help assess the condition of items returned through buy-back programs. They can automate the evaluation process, separating items that can be resold in good condition from those that may need refurbishing.

Lastly, since machine learning algorithms has the ability to analyze very large datasets of consumer behaviours. A machine learning algorithm can be implemented to monitor the broader resale market, providing the clothing brands with insights into trends, pricing, and demand for pre-loved items. Clothing brands can then adjust their marketing strategies based on the information the machine learning algorithm provides.

In conclusion, machine learning is a versatile and practical tool with applications in business, finance, medical, and many other sectors. For clothing brands, machine learning can be a invaluable tool that can help the brand enhance the profitability and sustainability of their circular economy initiatives. Futhermore, it allows brands to provide more value to customers while also contributing to the overall reduction of waste in the fashion industry.

References

3 types of machine learning you should know. (n.d.). https://www.coursera.org/articles/types-of-machine-learning

Ahramovich, A. (n.d.). Machine learning in marketing: 10 use cases, examples amp; tips. https://www.itransition.com/machine-learning/marketing#:~:text=Machine%20learning%20enables%20marketers%20to,content%2C%20products%2C%20and%20services.

Arnx, A. (2019, August). First neural network for beginners explained (with code). https://towardsdatascience.com/first-neural-network-for-beginners-explained-with-code-4cfd37e06eaf

Consolidated financial statements year ended march 2021. (2021, March). https://salvationarmy.ca/wp-content/uploads/2023/07/ar_consolidated-financial-statement_2022-23_Eng.pdf

Consolidated financial statements year ended march 31, 2022. (2022, March). https://salvationarmy.ca/wp-content/uploads/2023/07/ar_consolidated-financial-statement_2022-23_Eng.pdf

Consolidated financial statements year ended march 31, 2023. (2023, March). https://salvationarmy.ca/wp-content/uploads/2023/07/ar_consolidated-financial-statement_2022-23_Eng.pdf

Scarffe, C. (2022). Price or quantity effect? the impacts of the pandemic on canadian trade.

Statistics Canada, C. (2023a). Table 12-10-0011-01 international merchandise trade for all countries and by principal trading partners, monthly (x 1,000,000)[data table]. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1210001101

Statistics Canada, C. (2023b, September). Table 36-10-0124-01 detailed household final consumption expenditure, canada, quarterly. https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=3610012401

What are neural networks? (n.d.). https://www.ibm.com/topics/neural-networks

What is machine learning? (n.d.). https://www.ibm.com/topics/machine-learning

Zanzana, S., & Martin, J. (2023, February). This follow-up study investigates how e-commerce and in-store retail sales evolved beyond the early stages of the covid-19 pandemic and precedes the transition to the 2022 north american industry classification system (naics) in the retail trade industry. in 2022, retail e-commerce sales continued to remain elevated above pre-pandemic levels in some subsectors, while in others, the resumption of in-store operations led consumers and businesses to transition closer to pre-pandemic shopping preferences. https://www150.statcan.gc.ca/n1/pub/11-621-m/11-621-m2023002-eng.htm

3 Code

Python Code

```
# %% [markdown]
# # ECON 607 Assignment 4

# %% [markdown]
# ## Import libraries

# %%
import __future__
print(__future__.all_feature_names)

from __future__ import absolute_import, division, print_function, unicode_literals

#tensorflow and keras
import tensorflow as tf
from tensorflow import keras

#helper libraries
import numpy as np
import matplotlib.pyplot as plt
import pandas

# %% [markdown]
# ## Ensure tensorflow has been loaded corrently

# %%
print(tf.__version__)

# %% [markdown]
# ## Import the MNIST dataset

# %%
fashion_mnist = keras.datasets.fashion_mnist
(train_images, train_labels), (test_images, test_labels) = fashion_mnist.load_data()

# %% [markdown]
# ## Create labels

# %% [markdown]
# ### Classify the Image groups

# %%
class_names = ['T-shirt/top', 'Trouser', 'Pullover', 'Dress', 'Coat', 'Sandal', 'Shirt', 'Sn
```

```
# %% [markdown]
# ## Data Preprocessing

# %% [markdown]
# ### Inspect source Data

# %%
plt.figure()
plt.imshow(train_images[0])
plt.colorbar()
plt.grid(False)
plt.show()


# %% [markdown]
# ### Scale Pixel Values

# %%
train_images = train_images / 255.0
test_images = test_images / 255.0

# %% [markdown]
# ### Inspect Data

# %%
plt.figure(figsize=(10,10))
for i in range(0,25):
    plt.subplot(5,5,i+1)
    plt.xticks([])
    plt.yticks([])
    plt.grid(False)
    plt.imshow(train_images[i], cmap=plt.cm.binary)
    plt.xlabel(class_names[train_labels[i]])
plt.show()

# %% [markdown]
# ## Building the NN Model

# %% [markdown]
# ### Set up the model layers

# %%
model = keras.Sequential([
    keras.layers.Flatten(input_shape=(28, 28)),
    keras.layers.Dense(128, activation='relu'),
```

```
    keras.layers.Dense(10, activation='softmax')
])

# %% [markdown]
# ### Compile the model

# %% [markdown]
# #### During the compile step the following are added:
# • Optimizer: how the model is updated based on the data it sees and
# its loss function
# <br>
# • Loss function: how accurate the model is during training
# <br>
# • Metrics: monitors the training and testing steps

# %%
model.compile(optimizer='adam',
              loss='sparse_categorical_crossentropy',
              metrics=['accuracy'])

# %% [markdown]
# ### Train the model

# %%
model.fit(train_images, train_labels, epochs=10)

# %% [markdown]
# ### Evaluate the accuracy

# %% [markdown]
# #### Compare how the model performs on the test dataset
# • The accuracy of the test data is less than the training data
# <br>
# • Overfitting: The gap between training accuracy and test accuracy

# %%
test_acc = model.evaluate(test_images, test_labels, verbose=2)
print("Test Accuracy:", test_acc)

# %% [markdown]
# ### Evaluate the first item

# %%
predictions = model.predict(test_images)
print(predictions[0])
image_index = np.argmax(predictions[0])
```

```
print("Predicted:", image_index, "Actual:", test_labels[0])
print(class_names[image_index])

# %% [markdown]
# ### Question 1

# %%
plt.figure()
plt.imshow(test_images[3456])
plt.colorbar()
plt.grid(False)
plt.show()

# %%
predictions_Q1 = model.predict(test_images)
print(predictions_Q1[3456])
image_index = np.argmax(predictions[3456])
print("Predicted:", image_index, "Actual:", test_labels[3456])
print(class_names[image_index])

# %%
```

R code

```
library("readr")
library(ggplot2)

expdata = read.table("/Users/andrew/Downloads/UW courses/ECON 607/Assignment 4/expdata.csv",

exp_num = expdata$Exports/1000


plot(expdata$Year, exp_num)
lines(exp_num)

plot1 = ggplot() +
  geom_line(aes(y = exp_num, x = expdata$Year), data = expdata, color='Red') +
  scale_x_continuous(breaks = seq(2008, 2022, 2)) +
  theme(text=element_text(family = "Tahoma"))

plot1 + labs(title = "Canadian Merchandise Export data",
             x = "Year", y = "Dollars of goods exported in billions",
             caption = "Graph created in R using data from Statistics Canada 2023")
```