Implement the Continuous Bag of Words (CBOW) Model. Stages can be:

a. Data preparation
b. Generate training data
c. Train model
d. Output

In [1]:
```
import numpy as np
import re
```

In [2]:
```
data = """Deep learning (also known as deep structured learning) is part of
on artificial neural networks with representation learning. Learning can be
Deep-learning architectures such as deep neural networks, deep belief networ
recurrent neural networks, convolutional neural networks and Transformers ha
speech recognition, natural language processing, machine translation, bioinf
climate science, material inspection and board game programs, where they hav
surpassing human expert performance."""
data
```

Out[2]:
```
'Deep learning (also known as deep structured learning) is part of a broad
er family of machine learning methods based on artificial neural networks
with representation learning. Learning can be supervised, semi-supervised
or unsupervised. Deep-learning architectures such as deep neural networks,
deep belief networks, deep reinforcement learning, recurrent neural networ
ks, convolutional neural networks and Transformers have been applied to fi
elds including computer vision, speech recognition, natural language proce
ssing, machine translation, bioinformatics, drug design, medical image ana
lysis, climate science, material inspection and board game programs, where
they have produced results comparable to and in some cases surpassing huma
n expert performance.'
```

In [3]:
```
sentences = data.split('.')
sentences
```

Out[3]:
```
['Deep learning (also known as deep structured learning) is part of a broa
der family of machine learning methods based on artificial neural networks
with representation learning',
 ' Learning can be supervised, semi-supervised or unsupervised',
 ' Deep-learning architectures such as deep neural networks, deep belief n
etworks, deep reinforcement learning, recurrent neural networks, convoluti
onal neural networks and Transformers have been applied to fields includin
g computer vision, speech recognition, natural language processing, machin
e translation, bioinformatics, drug design, medical image analysis, climat
e science, material inspection and board game programs, where they have pr
oduced results comparable to and in some cases surpassing human expert per
formance',
 '']
```

In [4]:
```
clean_sent=[]
for sentence in sentences:
    if sentence=="":
        continue
    sentence = re.sub('[^A-Za-z0-9]+', ' ', (sentence))
    sentence = re.sub(r'(?:^| )\w (?:$| )', ' ', (sentence)).strip()
    sentence = sentence.lower()
    clean_sent.append(sentence)

clean_sent
```

Out[4]:
```
['deep learning also known as deep structured learning is part of a broade
r family of machine learning methods based on artificial neural networks w
ith representation learning',
 'learning can be supervised semi supervised or unsupervised',
 'deep learning architectures such as deep neural networks deep belief net
works deep reinforcement learning recurrent neural networks convolutional
neural networks and transformers have been applied to fields including com
puter vision speech recognition natural language processing machine transl
ation bioinformatics drug design medical image analysis climate science ma
terial inspection and board game programs where they have produced results
comparable to and in some cases surpassing human expert performance']
```

In [5]:
```
from tensorflow.keras.preprocessing.text import Tokenizer
```

In [6]:
```
tokenizer = Tokenizer()
tokenizer.fit_on_texts(clean_sent)
sequences = tokenizer.texts_to_sequences(clean_sent)
print(sequences)
```

```
[[2, 1, 12, 13, 6, 2, 14, 1, 15, 16, 7, 17, 18, 19, 7, 8, 1, 20, 21, 22, 2
3, 4, 3, 24, 25, 1], [1, 26, 27, 9, 28, 9, 29, 30], [2, 1, 31, 32, 6, 2,
4, 3, 2, 33, 3, 2, 34, 1, 35, 4, 3, 36, 4, 3, 5, 37, 10, 38, 39, 11, 40, 4
1, 42, 43, 44, 45, 46, 47, 48, 8, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58,
59, 5, 60, 61, 62, 63, 64, 10, 65, 66, 67, 11, 5, 68, 69, 70, 71, 72, 73,
74]]
```

In [7]:
```
index_to_word = {}
word_to_index = {}

for i, sequence in enumerate(sequences):
#     print(sequence)
    word_in_sentence = clean_sent[i].split()
#     print(word_in_sentence)

    for j, value in enumerate(sequence):
        index_to_word[value] = word_in_sentence[j]
        word_to_index[word_in_sentence[j]] = value

print(index_to_word, "\n")
print(word_to_index)
```

```
{2: 'deep', 1: 'learning', 12: 'also', 13: 'known', 6: 'as', 14: 'structur
ed', 15: 'is', 16: 'part', 7: 'of', 17: 'a', 18: 'broader', 19: 'family',
8: 'machine', 20: 'methods', 21: 'based', 22: 'on', 23: 'artificial', 4:
'neural', 3: 'networks', 24: 'with', 25: 'representation', 26: 'can', 27:
'be', 9: 'supervised', 28: 'semi', 29: 'or', 30: 'unsupervised', 31: 'arch
itectures', 32: 'such', 33: 'belief', 34: 'reinforcement', 35: 'recurren
t', 36: 'convolutional', 5: 'and', 37: 'transformers', 10: 'have', 38: 'be
en', 39: 'applied', 11: 'to', 40: 'fields', 41: 'including', 42: 'compute
r', 43: 'vision', 44: 'speech', 45: 'recognition', 46: 'natural', 47: 'lan
guage', 48: 'processing', 49: 'translation', 50: 'bioinformatics', 51: 'dr
ug', 52: 'design', 53: 'medical', 54: 'image', 55: 'analysis', 56: 'climat
e', 57: 'science', 58: 'material', 59: 'inspection', 60: 'board', 61: 'gam
e', 62: 'programs', 63: 'where', 64: 'they', 65: 'produced', 66: 'result
s', 67: 'comparable', 68: 'in', 69: 'some', 70: 'cases', 71: 'surpassing',
72: 'human', 73: 'expert', 74: 'performance'}

{'deep': 2, 'learning': 1, 'also': 12, 'known': 13, 'as': 6, 'structured':
14, 'is': 15, 'part': 16, 'of': 7, 'a': 17, 'broader': 18, 'family': 19,
'machine': 8, 'methods': 20, 'based': 21, 'on': 22, 'artificial': 23, 'neu
ral': 4, 'networks': 3, 'with': 24, 'representation': 25, 'can': 26, 'be':
27, 'supervised': 9, 'semi': 28, 'or': 29, 'unsupervised': 30, 'architectu
res': 31, 'such': 32, 'belief': 33, 'reinforcement': 34, 'recurrent': 35,
'convolutional': 36, 'and': 5, 'transformers': 37, 'have': 10, 'been': 38,
'applied': 39, 'to': 11, 'fields': 40, 'including': 41, 'computer': 42, 'v
ision': 43, 'speech': 44, 'recognition': 45, 'natural': 46, 'language': 4
7, 'processing': 48, 'translation': 49, 'bioinformatics': 50, 'drug': 51,
'design': 52, 'medical': 53, 'image': 54, 'analysis': 55, 'climate': 56,
'science': 57, 'material': 58, 'inspection': 59, 'board': 60, 'game': 61,
'programs': 62, 'where': 63, 'they': 64, 'produced': 65, 'results': 66, 'c
omparable': 67, 'in': 68, 'some': 69, 'cases': 70, 'surpassing': 71, 'huma
n': 72, 'expert': 73, 'performance': 74}
```

In [8]:
```
vocab_size = len(tokenizer.word_index) + 1
emb_size = 10
context_size = 2

contexts = []
targets = []

for sequence in sequences:
    for i in range(context_size, len(sequence) - context_size):
        target = sequence[i]
        context = [sequence[i - 2], sequence[i - 1], sequence[i + 1], sequer
#         print(context)
        contexts.append(context)
        targets.append(target)
print(contexts, "\n")
print(targets)
```

```
[[2, 1, 13, 6], [1, 12, 6, 2], [12, 13, 2, 14], [13, 6, 14, 1], [6, 2, 1,
15], [2, 14, 15, 16], [14, 1, 16, 7], [1, 15, 7, 17], [15, 16, 17, 18], [1
6, 7, 18, 19], [7, 17, 19, 7], [17, 18, 7, 8], [18, 19, 8, 1], [19, 7, 1,
20], [7, 8, 20, 21], [8, 1, 21, 22], [1, 20, 22, 23], [20, 21, 23, 4], [2
1, 22, 4, 3], [22, 23, 3, 24], [23, 4, 24, 25], [4, 3, 25, 1], [1, 26, 9,
28], [26, 27, 28, 9], [27, 9, 9, 29], [9, 28, 29, 30], [2, 1, 32, 6], [1,
31, 6, 2], [31, 32, 2, 4], [32, 6, 4, 3], [6, 2, 3, 2], [2, 4, 2, 33], [4,
3, 33, 3], [3, 2, 3, 2], [2, 33, 2, 34], [33, 3, 34, 1], [3, 2, 1, 35],
[2, 34, 35, 4], [34, 1, 4, 3], [1, 35, 3, 36], [35, 4, 36, 4], [4, 3, 4,
3], [3, 36, 3, 5], [36, 4, 5, 37], [4, 3, 37, 10], [3, 5, 10, 38], [5, 37,
38, 39], [37, 10, 39, 11], [10, 38, 11, 40], [38, 39, 40, 41], [39, 11, 4
1, 42], [11, 40, 42, 43], [40, 41, 43, 44], [41, 42, 44, 45], [42, 43, 45,
46], [43, 44, 46, 47], [44, 45, 47, 48], [45, 46, 48, 8], [46, 47, 8, 49],
[47, 48, 49, 50], [48, 8, 50, 51], [8, 49, 51, 52], [49, 50, 52, 53], [50,
51, 53, 54], [51, 52, 54, 55], [52, 53, 55, 56], [53, 54, 56, 57], [54, 5
5, 57, 58], [55, 56, 58, 59], [56, 57, 59, 5], [57, 58, 5, 60], [58, 59, 6
0, 61], [59, 5, 61, 62], [5, 60, 62, 63], [60, 61, 63, 64], [61, 62, 64, 1
0], [62, 63, 10, 65], [63, 64, 65, 66], [64, 10, 66, 67], [10, 65, 67, 1
1], [65, 66, 11, 5], [66, 67, 5, 68], [67, 11, 68, 69], [11, 5, 69, 70],
[5, 68, 70, 71], [68, 69, 71, 72], [69, 70, 72, 73], [70, 71, 73, 74]]

[12, 13, 6, 2, 14, 1, 15, 16, 7, 17, 18, 19, 7, 8, 1, 20, 21, 22, 23, 4,
3, 24, 27, 9, 28, 9, 31, 32, 6, 2, 4, 3, 2, 33, 3, 2, 34, 1, 35, 4, 3, 36,
4, 3, 5, 37, 10, 38, 39, 11, 40, 41, 42, 43, 44, 45, 46, 47, 48, 8, 49, 5
0, 51, 52, 53, 54, 55, 56, 57, 58, 59, 5, 60, 61, 62, 63, 64, 10, 65, 66,
67, 11, 5, 68, 69, 70, 71, 72]
```

In [9]:
```
#printing features with target
for i in range(5):
    words = []
    target = index_to_word.get(targets[i])
    for j in contexts[i]:
        words.append(index_to_word.get(j))
    print(words," -> ", target)
```

```
['deep', 'learning', 'known', 'as']  ->  also
['learning', 'also', 'as', 'deep']  ->  known
['also', 'known', 'deep', 'structured']  ->  as
['known', 'as', 'structured', 'learning']  ->  deep
['as', 'deep', 'learning', 'is']  ->  structured
```

In [10]:
```
# Convert the contexts and targets to numpy arrays
X = np.array(contexts)
Y = np.array(targets)
```

In [11]:
```
# print(X)
```

In [12]:
```
import tensorflow as tf
from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Embedding, Lambda
```

In [13]:
```
model = Sequential([
    Embedding(input_dim=vocab_size, output_dim=emb_size, input_length=2*cont
    Lambda(lambda x: tf.reduce_mean(x, axis=1)),
    Dense(256, activation='relu'),
    Dense(512, activation='relu'),
    Dense(vocab_size, activation='softmax')
])
```

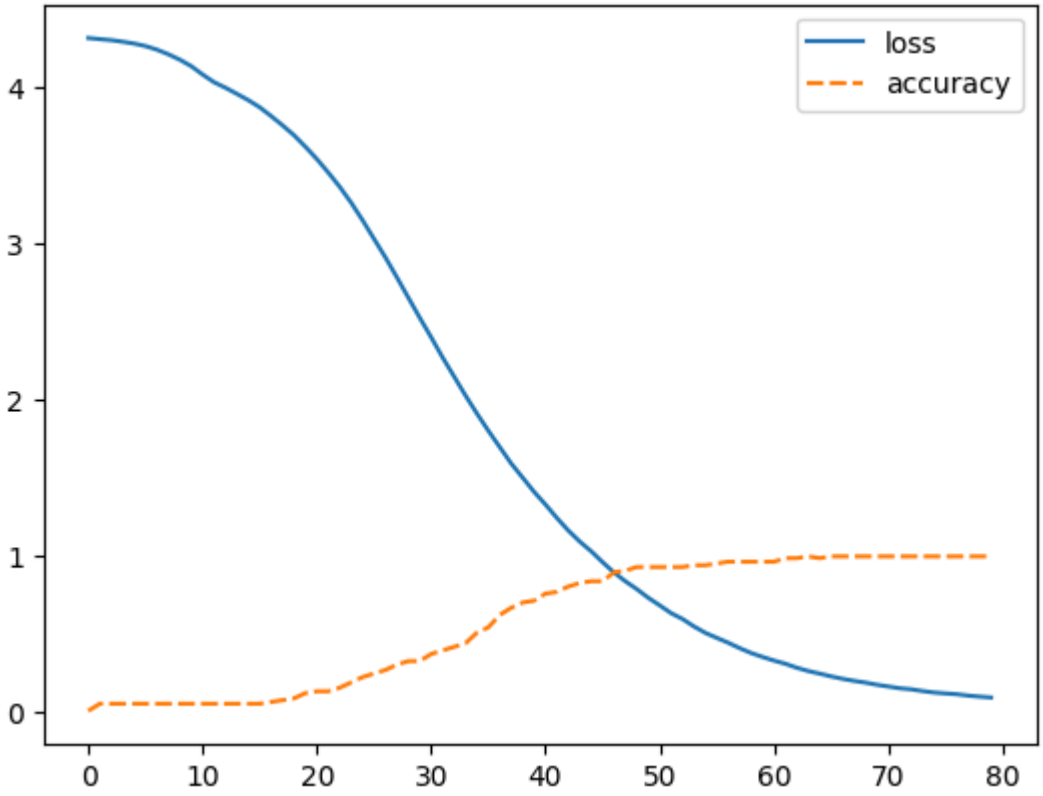
In [14]:
```
model.compile(loss='sparse_categorical_crossentropy', optimizer='adam', metr
```

In [15]:
```
history = model.fit(X, Y, epochs=80)
```

```
Epoch 1/80
3/3 [==============================] - 1s 13ms/step - loss: 4.3183 - acc
uracy: 0.0114
Epoch 2/80
3/3 [==============================] - 0s 5ms/step - loss: 4.3111 - accu
racy: 0.0568
Epoch 3/80
3/3 [==============================] - 0s 5ms/step - loss: 4.3047 - accu
racy: 0.0568
Epoch 4/80
3/3 [==============================] - 0s 8ms/step - loss: 4.2946 - accu
racy: 0.0568
Epoch 5/80
3/3 [==============================] - 0s 9ms/step - loss: 4.2827 - accu
racy: 0.0568
Epoch 6/80
3/3 [==============================] - 0s 4ms/step - loss: 4.2667 - accu
racy: 0.0568
Epoch 7/80
```

In [16]:
```
import seaborn as sns
sns.lineplot(model.history.history)
```

Out[16]: <Axes: >



In [17]:
```
from sklearn.decomposition import PCA

embeddings = model.get_weights()[0]

pca = PCA(n_components=2)
reduced_embeddings = pca.fit_transform(embeddings)
```

In [19]:
```
print("'Deep learning (also known as deep structured learning) is part of a
```

```
'Deep learning (also known as deep structured learning) is part of a broad
er family of machine learning methods based on artificial neural networks
with representation learning. Learning can be supervised, semi-supervised
or unsupervised. Deep-learning architectures such as deep neural networks,
deep belief networks, deep reinforcement learning, recurrent neural networ
ks, convolutional neural networks and Transformers have been applied to fi
elds including computer vision, speech recognition, natural language proce
ssing, machine translation, bioinformatics, drug design, medical image ana
lysis, climate science, material inspection and board game programs, where
they have produced results comparable to and in some cases surpassing huma
n expert performance.
```

In [18]:
```
# test model: select some sentences from above paragraph
test_sentenses = [
    "known as structured learning",
    "transformers have applied to",
    "where they produced results",
    "cases surpassing expert performance"
]
```

In [25]:
```
for sent in test_sentenses:
    test_words = sent.split(" ")
#     print(test_words)
    x_test =[]
    for i in test_words:
        x_test.append(word_to_index.get(i))
    x_test = np.array([x_test])
#     print(x_test)

    pred = model.predict(x_test)
    pred = np.argmax(pred[0])
    print("pred ", test_words, "\n=", index_to_word.get(pred),"\n\n")
```

```
1/1 [==============================] - 0s 66ms/step
pred  ['known', 'as', 'structured', 'learning']
= deep


1/1 [==============================] - 0s 53ms/step
pred  ['transformers', 'have', 'applied', 'to']
= been


1/1 [==============================] - 0s 52ms/step
pred  ['where', 'they', 'produced', 'results']
= have


1/1 [==============================] - 0s 55ms/step
pred  ['cases', 'surpassing', 'expert', 'performance']
= human
```

In [ ]: