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Perbandingan performa komputasi dan akurasi model Machine Learning, LSTM, dan BERT fine-tuning

Performa Komputasi:

Multinomial NB:

```
%%time
#algoritme fitting
text_algorithm = MultinomialNB()

model = text_algorithm.fit(x_train, y_train)

# save the model to disk
dump(model, filename="model_sentiment_naive.joblib")
```

```
CPU times: user 18.9 ms, sys: 2.01 ms, total: 20.9 ms
Wall time: 19.3 ms
```

SVM:

```
%%time
text_algorithm_svm = svm.SVC(kernel="rbf", C=1.0)
model_svm = text_algorithm_svm.fit(x_train, y_train)
dump(model_svm, filename="model_sentiment_svm.joblib")
```

```
CPU times: user 1.75 s, sys: 103 ms, total: 1.85 s
Wall time: 1.75 s
```

LSTM:

```
%%time
#model LSTM
from keras.models import Sequential
from keras.layers import Embedding, LSTM, Dense, Flatten
model = Sequential()
model.add(Embedding(10000,100, input_length = X.shape[1]))
model.add(LSTM(100))
model.add(Dense(3, activation='softmax'))
model.compile(loss='categorical_crossentropy', optimizer='adam', metrics=['accuracy'])
epochs = 5
batch_size = 64
history = model.fit(X_train, Y_train, epochs=epochs, batch_size=batch_size,validation_split=0.1)
```

```
Epoch 1/5
13/13 [==============================] - 4s 93ms/step - loss: 0.9947 - accuracy: 0.4659 - val_loss: 0.8698 - val_accuracy: 0.5652
Epoch 2/5
13/13 [==============================] - 1s 45ms/step - loss: 0.7928 - accuracy: 0.6509 - val_loss: 0.6774 - val_accuracy: 0.7283
Epoch 3/5
13/13 [==============================] - 1s 45ms/step - loss: 0.5744 - accuracy: 0.7908 - val_loss: 0.6269 - val_accuracy: 0.7717
Epoch 4/5
13/13 [==============================] - 1s 45ms/step - loss: 0.4300 - accuracy: 0.8589 - val_loss: 0.4834 - val_accuracy: 0.8261
Epoch 5/5
13/13 [==============================] - 1s 45ms/step - loss: 0.3218 - accuracy: 0.8966 - val_loss: 0.4389 - val_accuracy: 0.8261
CPU times: user 8.43 s, sys: 1.23 s, total: 9.65 s
Wall time: 9.91 s
```

BERT fine-tuning

```
%%time
bert_history = bert_model.fit(train_encoded, epochs=EPOCHS, batch_size=BATCH_SIZE, validation_data=val_encoded)
```

```
Epoch 1/5
29/29 [==============================] - 59s 1s/step - loss: 0.3967 - accuracy: 0.8425 - val_loss: 0.1489 - val_accuracy: 0.9474
Epoch 2/5
29/29 [==============================] - 31s 1s/step - loss: 0.1179 - accuracy: 0.9661 - val_loss: 0.1301 - val_accuracy: 0.9561
Epoch 3/5
29/29 [==============================] - 31s 1s/step - loss: 0.0423 - accuracy: 0.9880 - val_loss: 0.1595 - val_accuracy: 0.9474
Epoch 4/5
29/29 [==============================] - 31s 1s/step - loss: 0.0146 - accuracy: 0.9978 - val_loss: 0.1820 - val_accuracy: 0.9649
Epoch 5/5
29/29 [==============================] - 31s 1s/step - loss: 0.0150 - accuracy: 0.9945 - val_loss: 0.2179 - val_accuracy: 0.9474
CPU times: user 2min 5s, sys: 14.4 s, total: 2min 20s
Wall time: 3min 23s
```

Metrics Akurasi:

Multinomial NB:

```
Evaluasi model Multinomial NB
prediksi benar:  210  data
prediksi salah:  19  data
Akurasi Algoritme:  91.70305676855895 %
TRUE NEGATIVE (TN): 119
FALSE NEGATIVE (FN): 4
TRUE POSITIVE (TP): 59
FALSE POSITIVE (FP): 4
PRECISION: 93.65079365079364 %
RECALL: 93.65079365079364 %
```

	precision	recall	f1-score	support
0	0.95	0.94	0.95	126
1	0.89	0.89	0.89	66
2	0.84	0.86	0.85	37
accuracy			0.92	229
macro avg	0.90	0.90	0.90	229
weighted avg	0.92	0.92	0.92	229

SVM:

```
Evaluasi model SVM
prediksi benar:  208  data
prediksi salah:  21  data
Akurasi Algoritme:  90.82969432314411 %
TRUE NEGATIVE (TN): 121
FALSE NEGATIVE (FN): 8
TRUE POSITIVE (TP): 57
FALSE POSITIVE (FP): 3
PRECISION: 95.0 %
RECALL: 87.6923076923077 %
```

	precision	recall	f1-score	support
0	0.90	0.96	0.93	126
1	0.92	0.86	0.89	66
2	0.91	0.81	0.86	37
accuracy			0.91	229
macro avg	0.91	0.88	0.89	229
weighted avg	0.91	0.91	0.91	229

LSTM:

```
#LSTM
y_pred = np.argmax(model.predict(X_test), axis  =  1)
y_true = np.argmax(Y_test, axis = 1)
model_evaluation(y_pred, y_true)
```

```
prediksi benar:  207  data
prediksi salah:  22  data
Akurasi Algoritme:  90.39301310043668 %
TRUE NEGATIVE (TN): 121
FALSE NEGATIVE (FN): 7
TRUE POSITIVE (TP): 52
FALSE POSITIVE (FP): 2
PRECISION: 96.29629629629629 %
RECALL: 88.13559322033898 %
```

	precision	recall	f1-score	support
0	0.92	0.96	0.94	126
1	0.96	0.79	0.87	66
2	0.77	0.92	0.84	37
accuracy			0.90	229
macro avg	0.89	0.89	0.88	229
weighted avg	0.91	0.90	0.90	229

BERT fine-tuning:

```
score = bert_model.evaluate(test_encoded)

print("Test Accuracy:", score[1])
```

```
4/4 [==============================] - 1s 315ms/step - loss: 0.1511 - accuracy: 0.9478
Test Accuracy: 0.947826087474823
```

Berdasarkan performa komputasi yang dihasilkan, didapatkan penggunaan Machine Learning dengan model Multinomial NB dan SVM menghasilkan waktu komputasi sebesar 19.3ms dan 1.75s masing-masing. Lalu, pada model Deep Learning LSTM dihasilkan waktu komputasi 9.91s. Lalu pada penggunaan BERT fine-tuning, dihasilkan waktu komputasi sebesar 3m23s. Berdasarkan waktu komputasinya, model dengan performa terbaik adalah model Multinomial Naive Bayes, hal ini dikarenakan Multinomial Naive Bayes hanya melakukan perhitungan probabilitas dan cenderung berbentuk lebih sederhana (tidak memperhatikan semantik) bila

dibandingkan LSTM yang melakukan pembaharuan parameter dan BERT fine-tuning yang memperhatikan semantik kalimat.

Berdasarkan metrics akurasi, didapatkan metrics akurasi:

- Multinomial NB (ML) 91.7%
- SVM (ML) 90.8%
- LSTM 90.4%
- BERT fine-tuning 94.8%

Berdasarkan metrics akurasinya, didapat model terbaik adalah BERT fine-tuning. Dengan model BERT, semantik kata akan lebih diperhatikan dibandingkan dengan pendekatan Machine Learning. Bila menggunakan pemrograman tradisional, maka setiap kali terjadinya perubahan pada data akan memerlukan perubahan aturan pengolahan yang perlu didefinisikan yang menghasilkan tingkat efisiensi yang rendah, dan memiliki potensi menjadi kompleks berdasarkan kompleksitas data yang didapatkan.