Bahria University
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Parallel and Distributive Computing

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Task 2:

Consider two problems of classification/Regression. Acquire Datasets from Kaggle of Sentiment Analysis and Fraud Detection (Credit Card).

i. Apply Data parallelism by sending data to the GPU using CUDA.
ii. Apply Task Parallelism by using multi-threading.
Libraries to be used. Pandas, numpy, tensorflow

Solution:

```
import numpy as np
import pandas as pd
import tensorflow as tf
from tensorflow import keras
from tensorflow.keras import layers
import threading
```

```
# IMDb dataset (50,000 reviews, labeled positive/negative)
(x_train, y_train), (x_test, y_test) =
keras.datasets.imdb.load_data(num_words=10000)

# Pad sequences for equal length
x_train = keras.preprocessing.sequence.pad_sequences(x_train,
maxlen=200)
x_test = keras.preprocessing.sequence.pad_sequences(x_test, maxlen=200)
```

Output:

```
Downloading data from https://storage.googleapis.com/tensorflow/tf-keras-datasets/imdb.npz
17464789/17464789 ———————————— 2s 0us/step
```

```
def create_model():
    model = keras.Sequential([
        layers.Embedding(input_dim=10000, output_dim=64,
input_length=200),
        layers.LSTM(64),
        layers.Dense(1, activation='sigmoid')
    ])
    model.compile(optimizer="adam", loss="binary_crossentropy",
metrics=["accuracy"])
    return model
```

```
#Part I - Data Parallelism (CUDA)
with tf.device('/GPU:0'):    # Forces training on GPU
    model = create_model()
    history = model.fit(x_train, y_train, batch_size=512, epochs=2,
validation_split=0.2)
```

Output:

```
Epoch 1/2
/usr/local/lib/python3.12/dist-packages/keras/src/layers/core/embedding.py:97: UserWarning: Argument `input_length` is deprecated. Just remove it.
  warnings.warn(
40/40 ━━━━━━━━━━━━━━━━━━━━ 6s 32ms/step - accuracy: 0.5838 - loss: 0.6709 - val_accuracy: 0.7876 - val_loss: 0.4598
Epoch 2/2
40/40 ━━━━━━━━━━━━━━━━━━━━ 1s 23ms/step - accuracy: 0.8366 - loss: 0.3834 - val_accuracy: 0.8334 - val_loss: 0.3801
```

```
#Part II - Task Parallelism (Multi-threading)
from sklearn.datasets import fetch_openml
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler, OneHotEncoder
from sklearn.compose import ColumnTransformer
from sklearn.pipeline import Pipeline
import pandas as pd



def train_sentiment_model():
```

```
    with tf.device('/GPU:0'):
        model = create_model()
        model.fit(x_train, y_train, batch_size=512, epochs=2,
validation_split=0.2)
        print("Sentiment model training completed")
#########################################################################3
def load_credit_approval_dataset():
    data = fetch_openml("credit-g", version=1, as_frame=True)
    df = data.frame
    return df

def fraud_preprocessing_task():
    # Load dataset
    df = load_credit_approval_dataset()
    print("Original dataset shape:", df.shape)
    print("Class distribution:\n", df['class'].value_counts(), "\n")

    # Separate features and target
    X = df.drop("class", axis=1)
    y = (df["class"] == "bad").astype(int)  # encode: bad=1 (fraud),
good=0

    # Identify categorical vs numeric
    categorical_cols = X.select_dtypes(include=["category",
"object"]).columns
    numeric_cols = X.select_dtypes(exclude=["category",
"object"]).columns

    # Preprocessing: OneHot for categorical, StandardScaler for numeric
    preprocessor = ColumnTransformer(
        transformers=[
            ("num", StandardScaler(), numeric_cols),
            ("cat", OneHotEncoder(handle_unknown="ignore"),
categorical_cols)
        ]
    )

    # Pipeline
    pipeline = Pipeline(steps=[("preprocessor", preprocessor)])
```

```
    X_processed = pipeline.fit_transform(X)

    # Train-test split
    X_train, X_test, y_train, y_test = train_test_split(
        X_processed, y, test_size=0.2, stratify=y, random_state=42
    )

    print("After preprocessing:")
    print("Train set:", X_train.shape, " Test set:", X_test.shape)
    print("Fraud cases in train:", sum(y_train), " / in test:",
sum(y_test))

    return X_train, X_test, y_train, y_test
##########################################################3
# Run tasks in parallel using threads
t1 = threading.Thread(target=train_sentiment_model)
t2 = threading.Thread(target=fraud_preprocessing_task)

t1.start()
t2.start()

t1.join()
t2.join()
```

Output:

```
Original dataset shape: (1000, 21)
Class distribution:
class
good    700
bad     300
Name: count, dtype: int64

After preprocessing:
Train set: (800, 61)  Test set: (200, 61)
Fraud cases in train: 240  / in test: 60
Epoch 1/2
/usr/local/lib/python3.12/dist-packages/keras/src/layers/core/embedding.py:97: UserWarning: Argument `input_length` is deprecated. Just remove it.
  warnings.warn(
40/40 ━━━━━━━━━━━━━━━━━━━━ 2s 30ms/step - accuracy: 0.5865 - loss: 0.6618 - val_accuracy: 0.7986 - val_loss: 0.4370
Epoch 2/2
40/40 ━━━━━━━━━━━━━━━━━━━━ 1s 22ms/step - accuracy: 0.8396 - loss: 0.3690 - val_accuracy: 0.8438 - val_loss: 0.3615
Sentiment model training completed
```

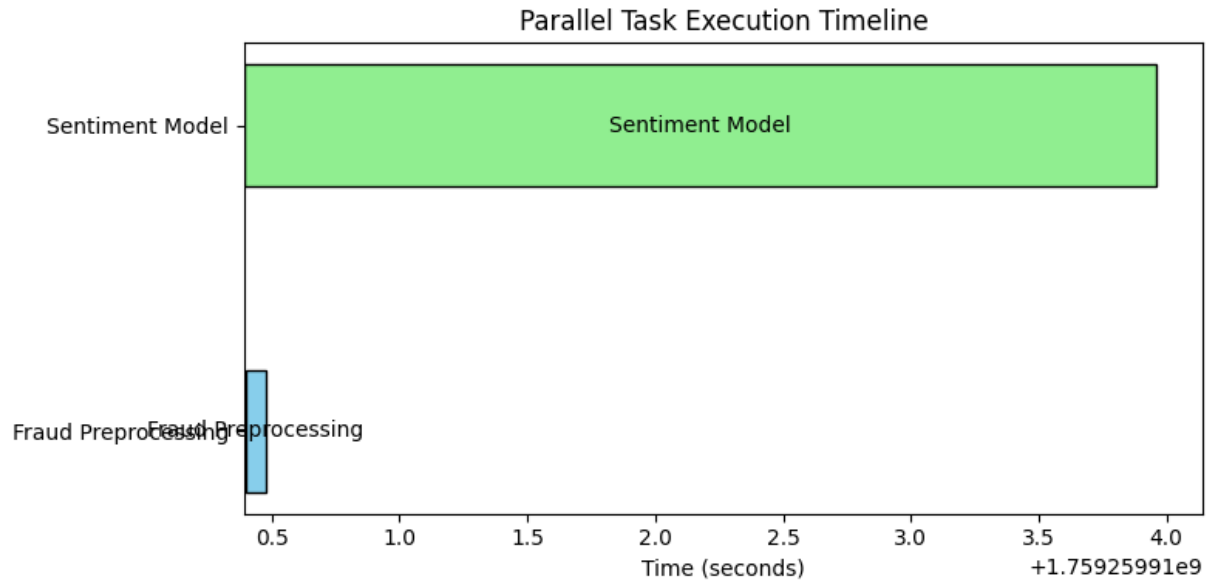
```
import threading
```

```
import time
import matplotlib.pyplot as plt

# --- Your Tasks ---
def train_sentiment_model():
    start = time.time()
    with tf.device('/GPU:0'):
        model = create_model()
        model.fit(x_train, y_train, batch_size=512, epochs=2,
validation_split=0.2)
        print("Sentiment model training completed")
    end = time.time()
    task_times["Sentiment Model"] = (start, end)

def load_credit_approval_dataset():
    data = fetch_openml("credit-g", version=1, as_frame=True)
    df = data.frame
    return df

def fraud_preprocessing_task():
    start = time.time()
    # Load dataset
    df = load_credit_approval_dataset()
    print("Original dataset shape:", df.shape)
    print("Class distribution:\n", df['class'].value_counts(), "\n")

    # Separate features and target
    X = df.drop("class", axis=1)
    y = (df["class"] == "bad").astype(int)  # encode: bad=1 (fraud),
good=0

    # Identify categorical vs numeric
    categorical_cols = X.select_dtypes(include=["category",
"object"]).columns
    numeric_cols = X.select_dtypes(exclude=["category",
"object"]).columns

    # Preprocessing: OneHot for categorical, StandardScaler for numeric
    preprocessor = ColumnTransformer(
```

```
        transformers=[
            ("num", StandardScaler(), numeric_cols),
            ("cat", OneHotEncoder(handle_unknown="ignore"),
categorical_cols)
        ]
    )

    # Pipeline
    pipeline = Pipeline(steps=[("preprocessor", preprocessor)])
    X_processed = pipeline.fit_transform(X)

    # Train-test split
    X_train, X_test, y_train, y_test = train_test_split(
        X_processed, y, test_size=0.2, stratify=y, random_state=42
    )

    print("After preprocessing:")
    print("Train set:", X_train.shape, " Test set:", X_test.shape)
    print("Fraud cases in train:", sum(y_train), " / in test:",
sum(y_test))
    end = time.time()
    task_times["Fraud Preprocessing"] = (start, end)

    return X_train, X_test, y_train, y_test


# Dictionary to store execution times
task_times = {}

# Run threads
t1 = threading.Thread(target=train_sentiment_model)
t2 = threading.Thread(target=fraud_preprocessing_task)

t1.start()
t2.start()
t1.join()
t2.join()

# --- Plot Gantt Chart ---
```

```
fig, ax = plt.subplots(figsize=(8,4))

colors = ["skyblue", "lightgreen"]
for i, (task, (start, end)) in enumerate(task_times.items()):
    ax.barh(y=i, width=end-start, left=start, height=0.4,
color=colors[i], edgecolor="black")
    ax.text((start+end)/2, i, task, ha="center", va="center",
fontsize=10, color="black")

ax.set_yticks([0, 1])
ax.set_yticklabels(list(task_times.keys()))
ax.set_xlabel("Time (seconds)")
ax.set_title("Parallel Task Execution Timeline")
plt.tight_layout()
plt.show()
```

Output:



Explanation:

Parallel Execution of Sentiment Model Training and Fraud Preprocessing

Thread 1: Sentiment Model Training

- Device: GPU
- Task: Train an LSTM neural network on IMDb movie reviews
- Data: 50,000 text reviews (positive/negative sentiment)
- Process:
  • Text preprocessing with an Embedding layer
  • LSTM sequence processing
  • Binary classification (sigmoid output)
- Duration: Longer running (neural network training)

Thread 2: Fraud Preprocessing

- Device: CPU
- Task: Preprocess credit approval dataset for fraud detection
- Data: Credit-g dataset with loan application data
- Process:
  • Load and clean financial data
  • Feature engineering (scaling numeric, encoding categorical)
  • Train-test split for fraud classification
- Duration: Shorter running (data preprocessing)

Parallel Execution Benefit

Both tasks run simultaneously:
- GPU handles compute-intensive neural network training
- CPU handles data loading and preprocessing
- Result: Reduced total execution time compared to sequential processing

The Gantt chart visualizes this overlap, showing how threading enables concurrent execution of different task types on appropriate hardware.