SETUP INICIAL - Instalar librerias y configurar Google Colab

```
# Instalar librerias necesarias
!pip install -q scikit-learn pandas numpy matplotlib seaborn
```

```
# Importar librerias
import pandas as pd
import numpy as np
import os
import pickle
import warnings
import matplotlib.pyplot as plt
import seaborn as sns

from sklearn.model_selection import train_test_split, cross_val_score, StratifiedKFold
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.preprocessing import LabelEncoder
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import (
    accuracy_score, precision_score, recall_score, f1_score,
    confusion_matrix, classification_report, roc_auc_score,
    roc_curve, auc
)

warnings.filterwarnings('ignore')

# Configurar visualizaciones
plt.style.use('seaborn-v0_8-darkgrid')
sns.set_palette("husl")

print("[OK] Librerias importadas exitosamente")
```

```
[OK] Librerias importadas exitosamente
```

```
# Configurar Google Colab (si aplica)
from google.colab import files
import shutil

print("[OK] Google Colab configurado")
print("\nINSTRUCCIONES PARA COLAB:")
print("1. Si tienes el archivo CSV localmente, ejecuta: files.upload()")
print("2. O copia el CSV a tu Google Drive y usa:")
print("   from google.colab import drive")
print("   drive.mount('/content/drive')")
print("3. Luego actualiza dataset_path a la ubicacion correcta")
```

```
[OK] Google Colab configurado

INSTRUCCIONES PARA COLAB:
1. Si tienes el archivo CSV localmente, ejecuta: files.upload()
2. O copia el CSV a tu Google Drive y usa:
   from google.colab import drive
   drive.mount('/content/drive')
3. Luego actualiza dataset_path a la ubicacion correcta
```

FASE 1: SAMPLE - Cargar y verificar datos

Objetivo: Cargar dataset original y validar estructura

```
print("\n" + "="*80)
print("FASE 1: SAMPLE - Cargar Dataset")
print("="*80)
print("Objetivo: Cargar 9,312 muestras del dataset CyberNative DPO")


dataset_path = '/content/cybernative_detector_training.csv'

print(f"\nCargando dataset desde: {dataset_path}")

try:
    df = pd.read_csv(dataset_path)
    print(f"[OK] Dataset cargado exitosamente")
except FileNotFoundError:
    print(f"[ERROR] Archivo no encontrado: {dataset_path}")
```

```
    print("Por favor ajusta la ruta dataset_path")
    df = None
```

```
================================================================================
FASE 1: SAMPLE - Cargar Dataset
================================================================================
Objetivo: Cargar 9,312 muestras del dataset CyberNative DPO

Cargando dataset desde: /content/cybernative_detector_training.csv
[OK] Dataset cargado exitosamente
```

```
# Validar estructura del dataset
print(f"\nTotal registros: {len(df):,}")
print(f"Total columnas: {df.shape[1]}")
print(f"\nColumnas: {list(df.columns)}")

# Verificar columnas requeridas
required_cols = ['codigo', 'lenguaje', 'vulnerable']
missing_cols = [col for col in required_cols if col not in df.columns]
if missing_cols:
    print(f"[ERROR] Faltan columnas: {missing_cols}")
else:
    print(f"[OK] Todas las columnas requeridas presentes")
```

```
Total registros: 9,312
Total columnas: 5

Columnas: ['codigo', 'lenguaje', 'tipo_vulnerabilidad', 'pregunta', 'vulnerable']
[OK] Todas las columnas requeridas presentes
```

```
# Analizar distribucion de clases
print("\nDistribucion de clases:")
class_counts = df['vulnerable'].value_counts()
for cls, count in class_counts.items():
    pct = (count / len(df)) * 100
    label = "Vulnerable" if cls == 1 else "Seguro"
    print(f"  - {label} ({cls}): {count:,} ({pct:.1f}%)")

# Analizar lenguajes
print(f"\nLenguajes en dataset: {df['lenguaje'].nunique()}")
print(f"Valores nulos totales: {df.isnull().sum().sum()}")
print(f"Duplicados: {df.duplicated().sum()}")

print("\n[OK] FASE 1 COMPLETADA")
```

```
Distribucion de clases:
  - Vulnerable (1): 4,656 (50.0%)
  - Seguro (0): 4,656 (50.0%)

Lenguajes en dataset: 11
Valores nulos totales: 0
Duplicados: 7

[OK] FASE 1 COMPLETADA
```

FASE 2: EXPLORE - Analisis exploratorio

Objetivo: Entender caracteristicas del dataset

```
print("\n" + "="*80)
print("FASE 2: EXPLORE - Analisis Estadistico")
print("="*80)

# Estadisticas de longitud de codigo
code_lengths = df['codigo'].str.len()
print(f"\nEstadisticas de longitud de codigo:")
print(f"  - Promedio: {code_lengths.mean():.0f} caracteres")
print(f"  - Mediana: {code_lengths.median():.0f} caracteres")
print(f"  - Minimo: {code_lengths.min()} caracteres")
print(f"  - Maximo: {code_lengths.max()} caracteres")
print(f"  - Desv. Est.: {code_lengths.std():.0f} caracteres")
```

```
================================================================================
FASE 2: EXPLORE - Analisis Estadistico
================================================================================
```

```
Estadisticas de longitud de codigo:
  - Promedio: 461 caracteres
  - Mediana: 369 caracteres
  - Minimo: 55 caracteres
  - Maximo: 8925 caracteres
  - Desv. Est.: 423 caracteres
```

```
# Distribucion de lenguajes
print(f"\nDistribucion de lenguajes:")
lang_dist = df['lenguaje'].value_counts()
for lang, count in lang_dist.items():
    pct = (count / len(df)) * 100
    print(f"  - {lang}: {count:,} ({pct:.1f}%)")
```

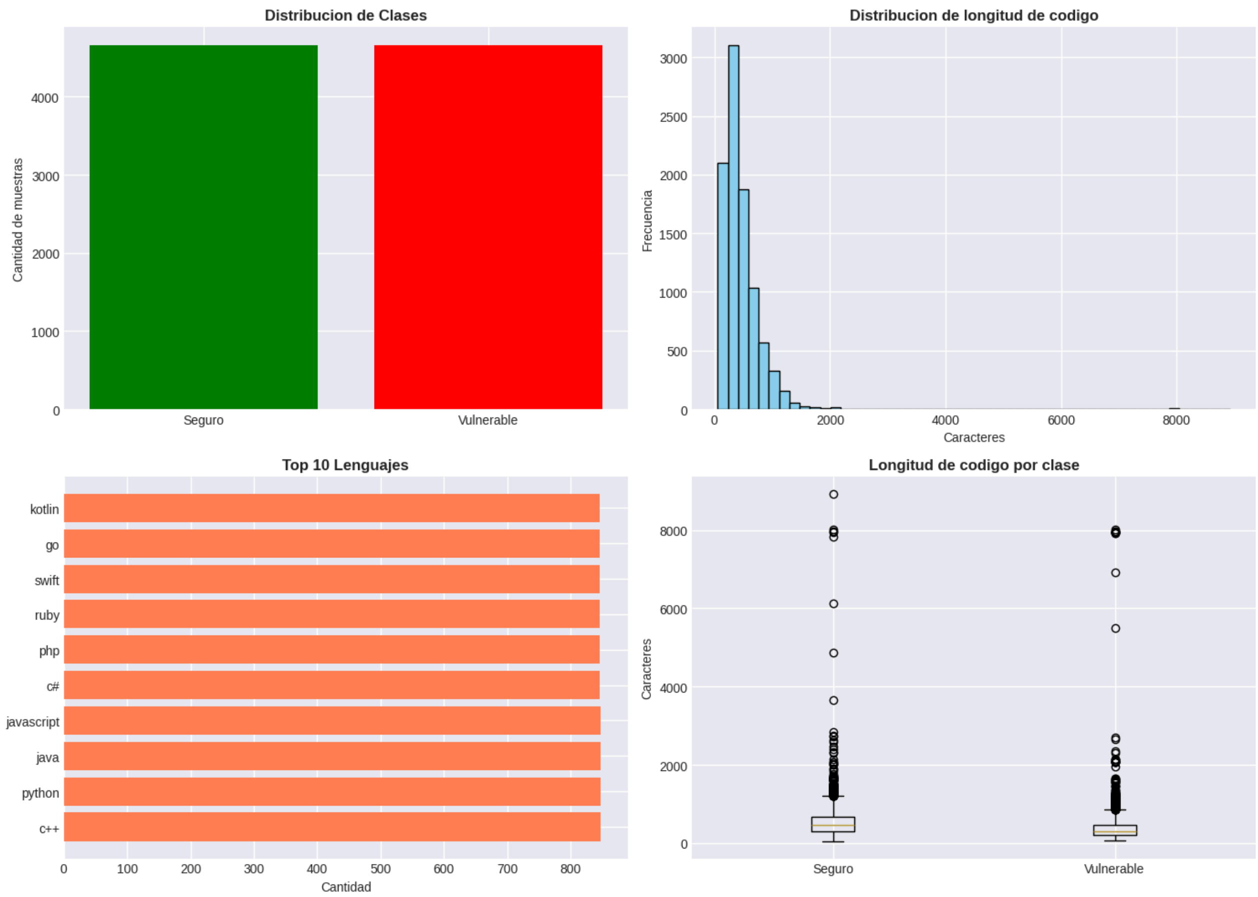
```
Distribucion de lenguajes:
  - c++: 848 (9.1%)
  - python: 848 (9.1%)
  - java: 848 (9.1%)
  - javascript: 848 (9.1%)
  - c#: 846 (9.1%)
  - php: 846 (9.1%)
  - ruby: 846 (9.1%)
  - swift: 846 (9.1%)
  - go: 846 (9.1%)
  - kotlin: 846 (9.1%)
  - fortran: 844 (9.1%)
```

```
# Balanceo de clases
vulnerable_count = (df['vulnerable'] == 1).sum()
safe_count = (df['vulnerable'] == 0).sum()
diff = abs(vulnerable_count - safe_count)

print(f"\nBalanceo de clases:")
print(f"  - Vulnerable: {vulnerable_count:,}")
print(f"  - Seguro: {safe_count:,}")
print(f"  - Diferencia: {diff} registros")
if diff < 100:
    print(f"  - Estado: BALANCEADO PERFECTO")
else:
    print(f"  - Estado: DESBALANCEADO")

print("\n[OK] FASE 2 COMPLETADA")
```

```
Balanceo de clases:
  - Vulnerable: 4,656
  - Seguro: 4,656
  - Diferencia: 0 registros
  - Estado: BALANCEADO PERFECTO

[OK] FASE 2 COMPLETADA
```

```
# Visualizaciones
fig, axes = plt.subplots(2, 2, figsize=(14, 10))

# Distribucion de clases
class_dist = df['vulnerable'].value_counts()
axes[0, 0].bar(['Seguro', 'Vulnerable'], [class_dist[0], class_dist[1]], color=['green', 'red'])
axes[0, 0].set_title('Distribucion de Clases', fontsize=12, fontweight='bold')
axes[0, 0].set_ylabel('Cantidad de muestras')

# Longitud de codigo
axes[0, 1].hist(code_lengths, bins=50, color='skyblue', edgecolor='black')
axes[0, 1].set_title('Distribucion de longitud de codigo', fontsize=12, fontweight='bold')
axes[0, 1].set_xlabel('Caracteres')
axes[0, 1].set_ylabel('Frecuencia')

# Top lenguajes
top_langs = lang_dist.head(10)
axes[1, 0].barh(top_langs.index, top_langs.values, color='coral')
axes[1, 0].set_title('Top 10 Lenguajes', fontsize=12, fontweight='bold')
axes[1, 0].set_xlabel('Cantidad')

# Longitud por clase
vulnerable_lengths = df[df['vulnerable'] == 1]['codigo'].str.len()
safe_lengths = df[df['vulnerable'] == 0]['codigo'].str.len()
axes[1, 1].boxplot([safe_lengths, vulnerable_lengths], labels=['Seguro', 'Vulnerable'])
axes[1, 1].set_title('Longitud de codigo por clase', fontsize=12, fontweight='bold')
axes[1, 1].set_ylabel('Caracteres')

plt.tight_layout()
plt.show()
```

```
print("Graficas generadas exitosamente")
```




```
Graficas generadas exitosamente
```

FASE 3: MODIFY - Feature Engineering

Objetivo: Preparar features para el modelo

```
print("\n" + "="*80)
print("FASE 3: MODIFY - Feature Engineering")
print("="*80)

# Extraer X y y
X_code = df['codigo'].values
X_lang = df['lenguaje'].values
y = df['vulnerable'].values

print(f"\nExtrayendo features...")
print(f"  - Total muestras: {len(X_code):,}")
print(f"  - Target variable: 0=Seguro, 1=Vulnerable")
```

```
================================================================================
FASE 3: MODIFY - Feature Engineering
================================================================================

Extrayendo features...
  - Total muestras: 9,312
  - Target variable: 0=Seguro, 1=Vulnerable
```

```
# Vectorizacion TF-IDF
print("\nFeature Engineering - TF-IDF:")
print("  - Max features: 1000")
print("  - N-grams: (1, 2) - unigramas + bigramas")
print("  - Stop words: English")
print("  - Sublinear TF: True")
print("  - Min DF: 2, Max DF: 0.95")
print("  - Vectorizando codigo...")

tfidf_vectorizer = TfidfVectorizer(
    max_features=1000,
    ngram_range=(1, 2),
    lowercase=True,
    stop_words='english',
    sublinear_tf=True,
    min_df=2,
    max_df=0.95
)

X_tfidf = tfidf_vectorizer.fit_transform(X_code)
print(f"[OK] Matriz TF-IDF shape: {X_tfidf.shape}")
```

```
Feature Engineering - TF-IDF:
  - Max features: 1000
  - N-grams: (1, 2) - unigramas + bigramas
  - Stop words: English
  - Sublinear TF: True
  - Min DF: 2, Max DF: 0.95
  - Vectorizando codigo...
[OK] Matriz TF-IDF shape: (9312, 1000)
```

```
# Language Encoding
print("\nFeature Engineering - Language Encoding:")
lang_encoder = LabelEncoder()
X_lang_encoded = lang_encoder.fit_transform(X_lang)
print(f"  - Lenguajes unicos: {len(lang_encoder.classes_)}")
print(f"  - Lenguajes: {', '.join(lang_encoder.classes_)}")
print(f"[OK] Language encoding completado")
```

```
Feature Engineering - Language Encoding:
  - Lenguajes unicos: 11
  - Lenguajes: c#, c++, fortran, go, java, javascript, kotlin, php, python, ruby, swift
[OK] Language encoding completado
```

```
# Combinar features
X_tfidf_dense = X_tfidf.toarray()
X_combined = np.column_stack([X_tfidf_dense, X_lang_encoded])
print(f"\nFeatures combinados:")
print(f"  - TF-IDF features: {X_tfidf_dense.shape[1]}")
print(f"  - Language features: 1")
print(f"  - Total features: {X_combined.shape[1]}")
print(f"  - Total muestras: {X_combined.shape[0]:,}")
```

```
Features combinados:
  - TF-IDF features: 1000
  - Language features: 1
  - Total features: 1001
  - Total muestras: 9,312
```

```
# Train/Test split
print(f"\nDividiendo en train/test (80/20, stratified)...")
X_train, X_test, y_train, y_test = train_test_split(
    X_combined, y,
    test_size=0.2,
    random_state=42,
    stratify=y
)

print(f"[OK] Split completado:")
print(f"  - Train: {len(X_train):,} muestras")
print(f"  - Test: {len(X_test):,} muestras")
print(f"  - Train class distribution: {np.bincount(y_train)}")
print(f"  - Test class distribution: {np.bincount(y_test)}")

print("\n[OK] FASE 3 COMPLETADA")
```

```
Dividiendo en train/test (80/20, stratified)...
[OK] Split completado:
  - Train: 7,449 muestras
```

```
  - Test: 1,863 muestras
  - Train class distribution: [3724 3725]
  - Test class distribution: [932 931]

[OK] FASE 3 COMPLETADA
```

FASE 4: MODEL - Entrenar RandomForest

Objetivo: Entrenar modelo de deteccion binaria

```
print("\n" + "="*80)
print("FASE 4: MODEL - Entrenar RandomForest")
print("="*80)

print("\nConfiguracion del modelo:")
print("  - Algoritmo: RandomForestClassifier")
print("  - N estimators: 200 arboles")
print("  - Max depth: 25")
print("  - Min samples split: 5")
print("  - Random state: 42")
print("  - N jobs: -1 (usar todos los cores)")

print("\nEntrenando modelo...")
model = RandomForestClassifier(
    n_estimators=200,
    max_depth=25,
    min_samples_split=5,
    random_state=42,
    n_jobs=-1,
    verbose=1
)

model.fit(X_train, y_train)
print("[OK] Modelo entrenado exitosamente")

print("\n[OK] FASE 4 COMPLETADA")
```

```
================================================================================
FASE 4: MODEL - Entrenar RandomForest
================================================================================

Configuracion del modelo:
  - Algoritmo: RandomForestClassifier
  - N estimators: 200 arboles
  - Max depth: 25
  - Min samples split: 5
  - Random state: 42
  - N jobs: -1 (usar todos los cores)

Entrenando modelo...
[Parallel(n_jobs=-1)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=-1)]: Done  46 tasks      | elapsed:    2.1s
[OK] Modelo entrenado exitosamente

[OK] FASE 4 COMPLETADA
[Parallel(n_jobs=-1)]: Done 196 tasks      | elapsed:    9.4s
[Parallel(n_jobs=-1)]: Done 200 out of 200 | elapsed:    9.6s finished
```

FASE 5: ASSESS - Evaluar performance

Objetivo: Evaluar metricas, K-Fold y análisis detallado

```
print("\n" + "="*80)
print("FASE 5: ASSESS - Evaluar Performance")
print("="*80)

print("\nGenerando predicciones...")
y_pred_train = model.predict(X_train)
y_pred_test = model.predict(X_test)
y_pred_proba = model.predict_proba(X_test)[:, 1]

# Metricas en train set
train_acc = accuracy_score(y_train, y_pred_train)
print(f"\nMETRICAS EN TRAIN SET:")
print(f"  - Accuracy: {train_acc:.4f} ({train_acc*100:.2f}%)")
```

```
================================================================================
FASE 5: ASSESS - Evaluar Performance
================================================================================

Generando predicciones...
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.1s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.6s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.6s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.1s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s

METRICAS EN TRAIN SET:
  - Accuracy: 0.8581 (85.81%)
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.1s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
```

```python
# K-Fold Cross-Validation
print("\nVALIDACION CRUZADA (5-Fold StratifiedKFold):")
kfold = StratifiedKFold(n_splits=5, shuffle=True, random_state=42)
cv_scores = cross_val_score(model, X_combined, y, cv=kfold, scoring='accuracy', n_jobs=-1)

for i, score in enumerate(cv_scores, 1):
    print(f"  - Fold {i}: {score:.4f}")
print(f"  - Promedio: {cv_scores.mean():.4f} (+/- {cv_scores.std():.4f})")
```

```
VALIDACION CRUZADA (5-Fold StratifiedKFold):
  - Fold 1: 0.7874
  - Fold 2: 0.7944
  - Fold 3: 0.7938
  - Fold 4: 0.7938
  - Fold 5: 0.7916
  - Promedio: 0.7922 (+/- 0.0026)
```

```python
# Metricas en test set
test_acc = accuracy_score(y_test, y_pred_test)
precision = precision_score(y_test, y_pred_test)
recall = recall_score(y_test, y_pred_test)
f1 = f1_score(y_test, y_pred_test)
roc_auc = roc_auc_score(y_test, y_pred_proba)

print(f"\nMETRICAS EN TEST SET:")
print(f"  - Accuracy:  {test_acc:.4f} ({test_acc*100:.2f}%)")
print(f"  - Precision: {precision:.4f} ({precision*100:.2f}%)")
print(f"  - Recall:    {recall:.4f} ({recall*100:.2f}%)")
print(f"  - F1-Score:  {f1:.4f} ({f1*100:.2f}%)")
print(f"  - ROC-AUC:   {roc_auc:.4f} ({roc_auc*100:.2f}%)")
```

```
METRICAS EN TEST SET:
  - Accuracy:  0.7901 (79.01%)
  - Precision: 0.7373 (73.73%)
  - Recall:    0.9012 (90.12%)
  - F1-Score:  0.8110 (81.10%)
  - ROC-AUC:   0.8883 (88.83%)
```

```python
# Matriz de confusion
print(f"\nMATRIZ DE CONFUSION (Test):")
cm = confusion_matrix(y_test, y_pred_test)
print(f"  - True Negatives (Seguro correcto):  {cm[0, 0]}")
print(f"  - False Positives (Falsa alarma):   {cm[0, 1]}")
print(f"  - False Negatives (Vulnerabilidad NO detectada): {cm[1, 0]}")
print(f"  - True Positives (Vulnerable correcto): {cm[1, 1]}")
```

```
MATRIZ DE CONFUSION (Test):
  - True Negatives (Seguro correcto):  633
  - False Positives (Falsa alarma):   299
  - False Negatives (Vulnerabilidad NO detectada): 92
  - True Positives (Vulnerable correcto): 839
```

```python
# Analisis de overfitting
overfitting = train_acc - test_acc
print(f"\nANALISIS DE OVERFITTING:")
print(f"  - Train Accuracy: {train_acc:.4f}")
print(f"  - Test Accuracy:  {test_acc:.4f}")
print(f"  - Diferencia:     {overfitting:.4f} ({overfitting*100:.2f}%)")
```

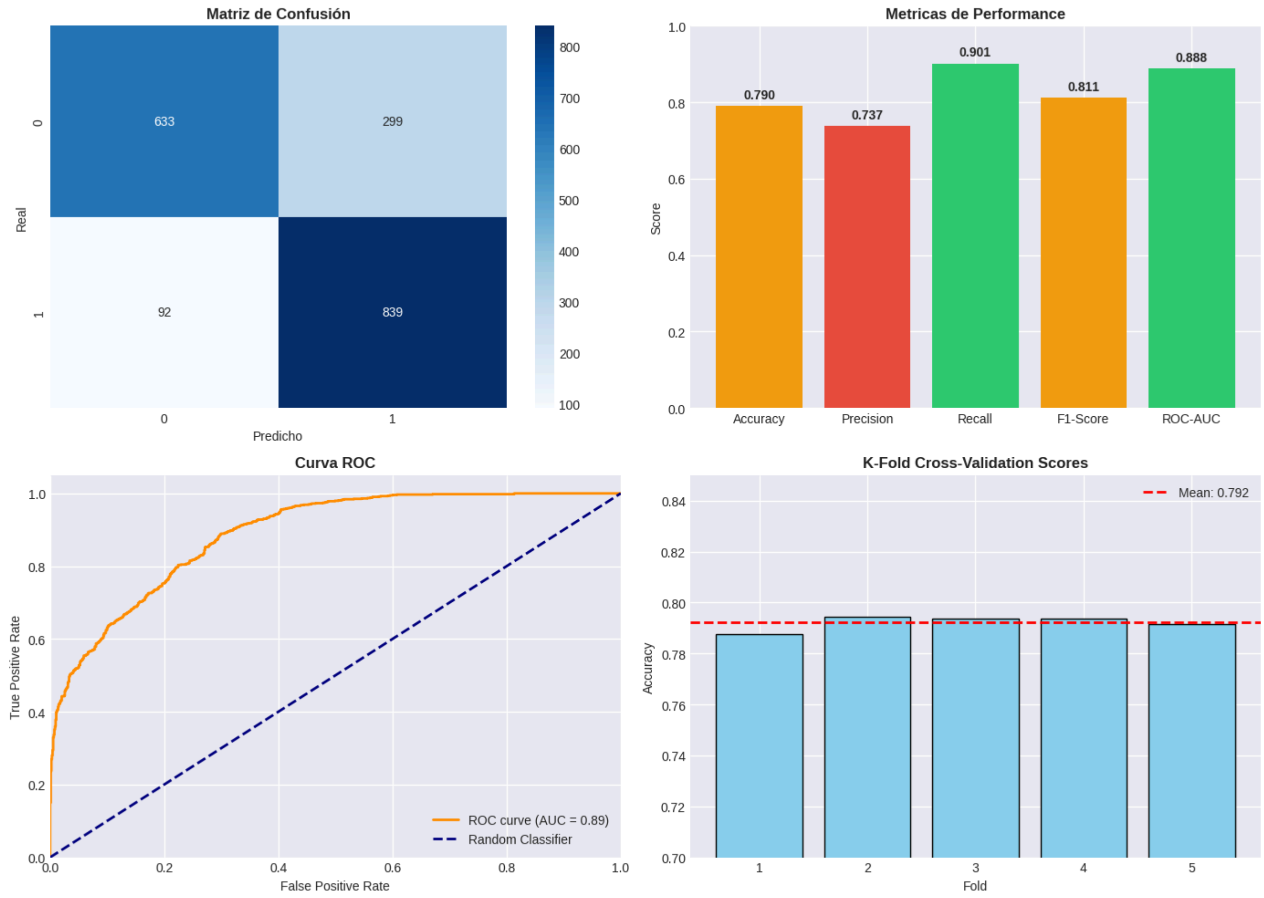
```
if overfitting < 0.10:
    print(f"  - Estado: ACEPTABLE (bajo overfitting)")
else:
    print(f"  - Estado: ADVERTENCIA (overfitting detectado)")
```

```
ANALISIS DE OVERFITTING:
  - Train Accuracy: 0.8581
  - Test Accuracy:  0.7901
  - Diferencia:     0.0680 (6.80%)
  - Estado: ACEPTABLE (bajo overfitting)
```

```
# Reporte de clasificacion
print(f"\nREPORTE DE CLASIFICACION:")
print(classification_report(y_test, y_pred_test, target_names=['Seguro (0)', 'Vulnerable (1)']))
```

```
REPORTE DE CLASIFICACION:
                precision    recall  f1-score   support

    Seguro (0)       0.87      0.68      0.76       932
Vulnerable (1)       0.74      0.90      0.81       931

      accuracy                           0.79      1863
     macro avg       0.81      0.79      0.79      1863
  weighted avg       0.81      0.79      0.79      1863
```

```
# Visualizaciones finales
fig, axes = plt.subplots(2, 2, figsize=(14, 10))

# Matriz de confusion
sns.heatmap(cm, annot=True, fmt='d', cmap='Blues', ax=axes[0, 0])
axes[0, 0].set_title('Matriz de Confusión', fontsize=12, fontweight='bold')
axes[0, 0].set_ylabel('Real')
axes[0, 0].set_xlabel('Predicho')

# Metricas
metricas = ['Accuracy', 'Precision', 'Recall', 'F1-Score', 'ROC-AUC']
valores = [test_acc, precision, recall, f1, roc_auc]
colores = ['#2ecc71' if v > 0.85 else '#f39c12' if v > 0.75 else '#e74c3c' for v in valores]
axes[0, 1].bar(metricas, valores, color=colores)
axes[0, 1].set_title('Metricas de Performance', fontsize=12, fontweight='bold')
axes[0, 1].set_ylabel('Score')
axes[0, 1].set_ylim([0, 1])
for i, v in enumerate(valores):
    axes[0, 1].text(i, v + 0.02, f'{v:.3f}', ha='center', fontweight='bold')

# ROC Curve
fpr, tpr, _ = roc_curve(y_test, y_pred_proba)
axes[1, 0].plot(fpr, tpr, color='darkorange', lw=2, label=f'ROC curve (AUC = {roc_auc:.2f})')
axes[1, 0].plot([0, 1], [0, 1], color='navy', lw=2, linestyle='--', label='Random Classifier')
axes[1, 0].set_xlim([0.0, 1.0])
axes[1, 0].set_ylim([0.0, 1.05])
axes[1, 0].set_xlabel('False Positive Rate')
axes[1, 0].set_ylabel('True Positive Rate')
axes[1, 0].set_title('Curva ROC', fontsize=12, fontweight='bold')
axes[1, 0].legend(loc="lower right")

# K-Fold scores
axes[1, 1].bar(range(1, 6), cv_scores, color='skyblue', edgecolor='black')
axes[1, 1].axhline(cv_scores.mean(), color='red', linestyle='--', linewidth=2, label=f'Mean: {cv_scores.mean():.3f}')
axes[1, 1].set_title('K-Fold Cross-Validation Scores', fontsize=12, fontweight='bold')
axes[1, 1].set_xlabel('Fold')
axes[1, 1].set_ylabel('Accuracy')
axes[1, 1].set_ylim([0.7, 0.85])
axes[1, 1].legend()

plt.tight_layout()
plt.show()

print("\nGraficas generadas exitosamente")
```




```
Graficas generadas exitosamente
```

```
print("\n[OK] FASE 5 COMPLETADA")
print("\n" + "="*80)
print("RESUMEN DEL ENTRENAMIENTO")
print("="*80)
print(f"\nPERFORMANCE FINAL:")
print(f"  - Test Accuracy:    {test_acc*100:.2f}%")
print(f"  - Test Recall:      {recall*100:.2f}% (detecta vulnerabilidades)")
print(f"  - Test ROC-AUC:     {roc_auc*100:.2f}%")
print(f"  - 5-Fold CV:        {cv_scores.mean()*100:.2f}% ± {cv_scores.std()*100:.2f}%")
print(f"  - Overfitting Gap:  {overfitting*100:.2f}%")
print(f"\nESTADO: ✅ MODELO ENTRENADO Y VALIDADO")
```

GUARDAR ARTEFACTOS (OPCIONAL)

Guardar modelos para usar en produccion

```
# Guardar modelos y vectorizadores
output_dir = '/content/drive/MyDrive/CVEfixes/models'  # Ajusta segun tu setup

try:
    os.makedirs(output_dir, exist_ok=True)

    # Guardar modelo
    with open(f'{output_dir}/vulnerability_detector.pkl', 'wb') as f:
        pickle.dump(model, f)

    # Guardar vectorizador
    with open(f'{output_dir}/vectorizer_detector.pkl', 'wb') as f:
        pickle.dump(tfidf_vectorizer, f)

    # Guardar encoder
    with open(f'{output_dir}/language_encoder.pkl', 'wb') as f:
        pickle.dump(lang_encoder, f)

    print(f"[OK] Modelos guardados en {output_dir}")
except Exception as e:
    print(f"[WARNING] No se pudieron guardar los modelos: {e}")
    print("Esto es normal si ejecutas en Colab sin Google Drive montado")
```

```
[OK] Modelos guardados en /content/drive/MyDrive/CVEfixes/models
```

INFERENCIA - Hacer predicciones con codigo nuevo

```
# Ejemplo de inferencia con nuevo codigo
print("\n" + "="*80)
print("EJEMPLO DE INFERENCIA")
print("="*80)

# Ejemplos de prueba
ejemplos = [
    ("int x = 5; x++;", "c++", "Seguro"),
    ("char buffer[10]; strcpy(buffer, user_input);", "c++", "Vulnerable - Buffer Overflow"),
    ("x = 10; print(x)", "python", "Seguro"),
    ("query = 'SELECT * FROM users WHERE id = ' + user_input", "python", "Vulnerable - SQL Injection"),
]

for codigo, lenguaje, etiqueta_real in ejemplos:
    print(f"\nCodigo: {codigo[:50]}...")
    print(f"Lenguaje: {lenguaje}")
    print(f"Etiqueta real: {etiqueta_real}")

    # Vectorizar
    features = tfidf_vectorizer.transform([codigo])
    lang_encoded = lang_encoder.transform([lenguaje])
    features_combined = np.column_stack([features.toarray(), lang_encoded])

    # Prediccion
    pred = model.predict(features_combined)[0]
    prob = model.predict_proba(features_combined)[0]

    pred_label = "Vulnerable" if pred == 1 else "Seguro"
    confianza = prob[pred]

    print(f"Prediccion: {pred_label} (Confianza: {confianza*100:.1f}%)")
    print(f"Probabilidades: Seguro={prob[0]:.3f}, Vulnerable={prob[1]:.3f}")
    print("-" * 80)
```

```
Codigo: int x = 5; x++;...
Lenguaje: c++
Etiqueta real: Seguro
Prediccion: Vulnerable (Confianza: 56.5%)
Probabilidades: Seguro=0.435, Vulnerable=0.565
--------------------------------------------------------------------------------

Codigo: char buffer[10]; strcpy(buffer, user_input);...
Lenguaje: c++
Etiqueta real: Vulnerable - Buffer Overflow
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.1s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.0s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.0s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.1s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.1s
[Parallel(n_jobs=2)]: Done 200 out of 200 | elapsed:    0.1s finished
Prediccion: Vulnerable (Confianza: 63.5%)




Etiqueta real: Seguro
```

```
Prediccion: Vulnerable (Confianza: 54.1%)
Probabilidades: Seguro=0.459, Vulnerable=0.541
--------------------------------------------------------------------------------

Codigo: query = 'SELECT * FROM users WHERE id = ' + user_i...
Lenguaje: python
Etiqueta real: Vulnerable - SQL Injection
Prediccion: Vulnerable (Confianza: 69.8%)
Probabilidades: Seguro=0.302, Vulnerable=0.698
--------------------------------------------------------------------------------
[Parallel(n_jobs=2)]: Using backend ThreadingBackend with 2 concurrent workers.
[Parallel(n_jobs=2)]: Done  46 tasks      | elapsed:    0.0s
[Parallel(n_jobs=2)]: Done 196 tasks      | elapsed:    0.1s
```