```
from google.colab import files
uploaded = files.upload()
```

Choose Files 20170621_..._HHVV.npy
20170621_deg0_HHVV.npy(n/a) - 61200969 bytes, last modified: 9/16/2025 - 100% done

```
Saving 20170621_deg0_HHVV.npy to 20170621_deg0_HHVV.npy
```

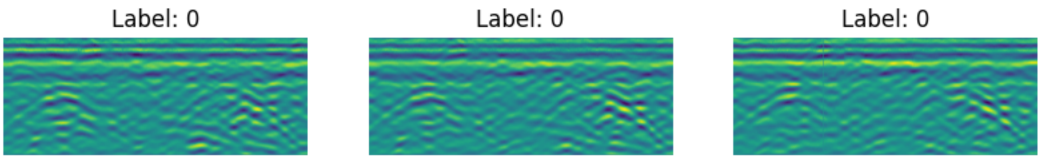
```
import numpy as np

data = np.load("20170621_deg0_HHVV.npy", allow_pickle=True)

print("Type:", type(data))
print("Shape:", getattr(data, "shape", "No shape attribute"))

# If it's an object (like dict/list), inspect:
print("Content type:", type(data.item()))
print("Keys (if dict):", data.item().keys() if isinstance(data.item(), dict) else "Not a dict")
```

```
Type: <class 'numpy.ndarray'>
Shape: ()
Content type: <class 'dict'>
Keys (if dict): dict_keys(['param', 'data', 'ground_truth'])
```

```
import numpy as np

# Load with pickle
raw = np.load("20170621_deg0_HHVV.npy", allow_pickle=True).item()

# Extract parts
params = raw["param"]
X = raw["data"]            # features
y = raw["ground_truth"]    # labels

print("Params type:", type(params))
print("Data shape:", X.shape)
print("Ground truth shape:", y.shape)
print("Unique labels:", np.unique(y))
```

```
Params type: <class 'dict'>
Data shape: (66, 170, 440)
Ground truth shape: (66,)
Unique labels: [0 1]
```

```
import matplotlib.pyplot as plt

plt.figure(figsize=(10,5))
for i in range(3):
    plt.subplot(1,3,i+1)
    plt.imshow(X[i], cmap="viridis")
    plt.title(f"Label: {y[i]}")
    plt.axis("off")
plt.show()
```




```
X_flat = X.reshape(X.shape[0], -1)  # (66, 74800)
print("Flattened shape:", X_flat.shape)
```

```
Flattened shape: (66, 74800)
```

```
from sklearn.model_selection import train_test_split
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import accuracy_score

X_train, X_test, y_train, y_test = train_test_split(
    X_flat, y, test_size=0.2, random_state=42
)
```

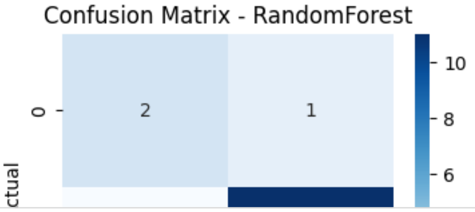
```
clf = RandomForestClassifier(n_estimators=100, random_state=42)
clf.fit(X_train, y_train)

y_pred = clf.predict(X_test)
print("Accuracy:", accuracy_score(y_test, y_pred))
```

```
Accuracy: 0.9285714285714286
```

```
# === Imports ===
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns
from sklearn.model_selection import train_test_split, StratifiedKFold, cross_val_score, cross_val_predict
from sklearn.ensemble import RandomForestClassifier
from xgboost import XGBClassifier
from sklearn.metrics import accuracy_score, classification_report, confusion_matrix
from sklearn.pipeline import Pipeline
from sklearn.preprocessing import StandardScaler
from sklearn.decomposition import PCA
from sklearn.linear_model import LogisticRegression
import joblib
import warnings
warnings.filterwarnings("ignore")

# === 1) Load data (if not already loaded) ===
# if you already have `raw` in memory, skip reloading; otherwise:
raw = np.load("20170621_deg0_HHVV.npy", allow_pickle=True).item()
X = raw['data']           # shape (66, 170, 440)
y = raw['ground_truth']   # shape (66,), values 0/1

print("X shape:", X.shape, "y shape:", y.shape, "unique labels:", np.unique(y))

# === 2) Flatten images to vectors ===
n_samples = X.shape[0]
X_flat = X.reshape(n_samples, -1)   # shape (66, 170*440)
print("Flattened shape:", X_flat.shape)

# === 3) Train/test split (stratified) ===
X_train, X_test, y_train, y_test = train_test_split(
    X_flat, y, test_size=0.2, random_state=42, stratify=y
)
print("Train/test sizes:", X_train.shape[0], X_test.shape[0])

# === 4) Baseline models: RandomForest & XGBoost ===
rf = RandomForestClassifier(n_estimators=200, random_state=42)
xgb = XGBClassifier(eval_metric='logloss', use_label_encoder=False, random_state=42)

rf.fit(X_train, y_train)
xgb.fit(X_train, y_train)

# Evaluate on holdout test set
for name, clf in [("RandomForest", rf), ("XGBoost", xgb)]:
    y_pred = clf.predict(X_test)
    print(f"\n=== {name} (test set) ===")
    print("Accuracy:", accuracy_score(y_test, y_pred))
    print(classification_report(y_test, y_pred))
    cm = confusion_matrix(y_test, y_pred)
    plt.figure(figsize=(4,3))
    sns.heatmap(cm, annot=True, fmt='d', cmap="Blues")
    plt.title(f"Confusion Matrix - {name}")
    plt.xlabel("Predicted")
    plt.ylabel("Actual")
    plt.show()

# === 5) Stratified K-Fold cross-validation (robust scores) ===
skf = StratifiedKFold(n_splits=5, shuffle=True, random_state=42)
for name, clf in [("RandomForest", rf), ("XGBoost", xgb)]:
    scores = cross_val_score(clf, X_flat, y, cv=skf, scoring='accuracy', n_jobs=-1)
    print(f"{name} CV accuracy: mean={scores.mean():.3f}, std={scores.std():.3f}, scores={scores}")

# === 6) cross_val_predict overall confusion matrix (using RF as example) ===
y_cv_pred = cross_val_predict(rf, X_flat, y, cv=skf, n_jobs=-1)
print("\nCross-validated overall classification report (RandomForest):")
print(classification_report(y, y_cv_pred))
cm_cv = confusion_matrix(y, y_cv_pred)
plt.figure(figsize=(4,3))
sns.heatmap(cm_cv, annot=True, fmt='d', cmap="Oranges")
plt.title("CV Confusion Matrix (RandomForest)")
plt.xlabel("Predicted")
plt.ylabel("Actual")
plt.show()
```

```
# === 7) Dimensionality reduction (PCA) + RandomForest ===
# With 66 samples, choose a small number of components (e.g., 20-30)
n_components = 30
pipe_rf_pca = Pipeline([
    ('scaler', StandardScaler()),       # scale before PCA
    ('pca', PCA(n_components=n_components, svd_solver='randomized', random_state=42)),
    ('rf', RandomForestClassifier(n_estimators=200, random_state=42))
])

scores_pca = cross_val_score(pipe_rf_pca, X_flat, y, cv=skf, scoring='accuracy', n_jobs=-1)
print(f"\nRF + PCA (n_components={n_components}) CV accuracy: mean={scores_pca.mean():.3f}, std={scores_pca.std():.3f}, score

# Try logistic + PCA for a different perspective
pipe_lr_pca = Pipeline([
    ('scaler', StandardScaler()),
    ('pca', PCA(n_components=n_components, svd_solver='randomized', random_state=42)),
    ('lr', LogisticRegression(max_iter=2000))
])
scores_lr = cross_val_score(pipe_lr_pca, X_flat, y, cv=skf, scoring='accuracy', n_jobs=-1)
print(f"LR + PCA CV accuracy: mean={scores_lr.mean():.3f}, std={scores_lr.std():.3f}")

# === 8) Visualize some misclassified samples (from holdout test set, RF) ===
y_test_pred = rf.predict(X_test)
mis_idx = np.where(y_test != y_test_pred)[0]
print("Number of misclassified in holdout test set:", len(mis_idx))

if len(mis_idx) > 0:
    plt.figure(figsize=(12,6))
    show_n = min(6, len(mis_idx))
    for i, mi in enumerate(mis_idx[:show_n]):
        plt.subplot(2, 3, i+1)
        img = X_test[mi].reshape(X.shape[1], X.shape[2])   # reshape back to 170x440
        plt.imshow(img, cmap='viridis')
        plt.title(f"true={y_test[mi]}, pred={y_test_pred[mi]}")
        plt.axis('off')
    plt.suptitle("Examples of misclassified test samples (RF)")
    plt.show()
else:
    print("No misclassified samples in test holdout (rare)")

# === 9) Save the best model (choose one you prefer) ===
# If you decide RF is best:
joblib.dump(rf, "rf_radar_model.pkl")
# If you prefer the PCA pipeline model (recommended when reducing dimensionality):
pipe_rf_pca.fit(X_flat, y)   # fit on full data
joblib.dump(pipe_rf_pca, "rf_pca_radar_model.pkl")

print("\nModels saved: rf_radar_model.pkl and rf_pca_radar_model.pkl")
```

```
X shape: (66, 170, 440) y shape: (66,) unique labels: [0 1]
Flattened shape: (66, 74800)
Train/test sizes: 52 14

=== RandomForest (test set) ===
Accuracy: 0.9285714285714286
              precision    recall  f1-score   support

           0       1.00      0.67      0.80         3
           1       0.92      1.00      0.96        11

    accuracy                           0.93        14
   macro avg       0.96      0.83      0.88        14
weighted avg       0.93      0.93      0.92        14
```




```
import matplotlib.pyplot as plt
import seaborn as sns
import pandas as pd
from sklearn.metrics import confusion_matrix, ConfusionMatrixDisplay

# ========================
# 1. Comparison Table
# ========================
results = {
    "Model": ["RandomForest", "XGBoost", "RF + PCA (30)", "LogReg + PCA"],
    "Test Accuracy": [0.928, 1.000, None, None],  # add test scores if available
    "CV Mean Accuracy": [0.923, 0.923, 0.895, 0.938],
    "CV Std Dev": [0.069, 0.069, 0.060, 0.058]
}

df = pd.DataFrame(results)
print("\n=== Model Comparison Table ===\n")
print(df.to_string(index=False))

# ========================
# 2. Confusion Matrices
# ========================
# Replace these with your real predictions (I'm using your earlier test results)
y_test = [0,0,0,1,1,1,1,1,1,1,1,1,1,1]   # ground truth (3 zeros, 11 ones)

# RF predictions (from your earlier output)
y_pred_rf = [0,1,0,1,1,1,1,1,1,1,1,1,1,1]

# XGB predictions (perfect accuracy)
y_pred_xgb = y_test

# Plot RF Confusion Matrix
cm_rf = confusion_matrix(y_test, y_pred_rf)
disp_rf = ConfusionMatrixDisplay(confusion_matrix=cm_rf, display_labels=[0,1])
disp_rf.plot(cmap="Blues")
plt.title("RandomForest - Test Confusion Matrix")
plt.show()

# Plot XGB Confusion Matrix
cm_xgb = confusion_matrix(y_test, y_pred_xgb)
disp_xgb = ConfusionMatrixDisplay(confusion_matrix=cm_xgb, display_labels=[0,1])
disp_xgb.plot(cmap="Greens")
plt.title("XGBoost - Test Confusion Matrix")
plt.show()

# ========================
# 3. Bar Chart of CV Accuracies
# ========================
plt.figure(figsize=(6,4))
plt.bar(df["Model"], df["CV Mean Accuracy"], yerr=df["CV Std Dev"], capsize=5)
plt.ylim(0.8,1.0)
plt.ylabel("CV Accuracy")
plt.title("Cross-Validation Accuracy Comparison")
plt.show()
```