```
!pip -q install lightgbm catboost xgboost
```

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt

from sklearn.model_selection import StratifiedKFold
from sklearn.metrics import roc_auc_score, roc_curve, auc

import xgboost as xgb
import lightgbm as lgb
from catboost import CatBoostClassifier

import warnings
warnings.filterwarnings("ignore")

print("OK: imports loaded")
```

```
OK: imports loaded
```

```
data_dir = "."

train = pd.read_csv(f"{data_dir}/train.csv")
test = pd.read_csv(f"{data_dir}/test.csv")
sample_sub = pd.read_csv(f"{data_dir}/sample_submission.csv")

target = "diagnosed_diabetes"
id_col = "id"

print(train.shape, test.shape, sample_sub.shape)
train.head()
```

```
features = [c for c in train.columns if c not in [target, id_col]]
X_df = train[features].copy()
X_test_df = test[features].copy()

cols_to_impute = [
        "bmi", "systolic_bp", "diastolic_bp", "heart_rate",
        "cholesterol_total",  "hdl_cholesterol",  "ldl_cholesterol",  "triglycerides"
]

for  col  in  cols_to_impute:
        if  col  in  X_df.columns:
                median_val  =  train.loc[train[col]  >  0,  col].median()
                X_df.loc[X_df[col]  <=  0,  col]  =  median_val
                X_test_df.loc[X_test_df[col]  <=  0,  col]  =  median_val

print("OK:  imputation  done")
```

```
OK: imputation done
```

```
def  add_features(df:  pd.DataFrame)  ->  pd.DataFrame:
        df  =  df.copy()

        #  interaction
        if  "bmi"  in  df.columns  and  "waist_to_hip_ratio"  in  df.columns:
                df["bmi_waist_ratio"]  =  df["bmi"]  *  df["waist_to_hip_ratio"]

        if  "age"  in  df.columns  and  "physical_activity_minutes_per_week"  in  df.columns:
                df["age_activity"]  =  df["age"]  *  df["physical_activity_minutes_per_week"]

        if  "sleep_hours_per_day"  in  df.columns  and  "screen_time_hours_per_day"  in  df.columns:
                df["sleep_screen_ratio"]  =  df["sleep_hours_per_day"]  /  (df["screen_time_hours_per

        #  clinical
        if  "systolic_bp"  in  df.columns  and  "diastolic_bp"  in  df.columns:
                df["bp_mean"]  =  (2  *  df["diastolic_bp"]  +  df["systolic_bp"])  /  3

        if  "hdl_cholesterol"  in  df.columns  and  "cholesterol_total"  in  df.columns:
                df["cholesterol_ratio"]  =  df["hdl_cholesterol"]  /  (df["cholesterol_total"]  +  1e

        #  discretization
        if  "age"  in  df.columns:
                df["age_group"]  =  pd.cut(df["age"],  bins=[20,  35,  50,  65,  80],
                                                                                  labels=[1,  2,  3,  4],  right=Fals

        if  "bmi"  in  df.columns:
                df["bmi_category"]  =  pd.cut(df["bmi"],  bins=[0,  18.5,  25,  30,  35,  100],
                                                                                        labels=[1,  2,  3,  4,  5],
        return  df

X_df  =  add_features(X_df)
X_test_df  =  add_features(X_test_df)

print("OK:  feature  engineering  done")
```

```
OK: feature engineering done
```

```
cat_cols  =  X_df.select_dtypes(include=["object"]).columns.tolist()

X_all  =  pd.concat([X_df,  X_test_df],  axis=0)
X_all_encoded  =  pd.get_dummies(X_all,  columns=cat_cols,  drop_first=False)
```

```
X_encoded = X_all_encoded.iloc[:len(train)].reset_index(drop=True)
X_test_encoded = X_all_encoded.iloc[len(train):].reset_index(drop=True)

feature_names = X_encoded.columns.to_list()

X = X_encoded.values
X_test = X_test_encoded.values
y = train[target].values

pos = y.sum()
neg = len(y) - pos
scale_pos_weight = neg / pos

print("Features total:", X_encoded.shape[1])
print(f"Positive: {pos}, Negative: {neg}, scale_pos_weight={scale_pos_weight:.3f}")
```

```
Features total: 49
Positive: 436307.0, Negative: 263693.0, scale_pos_weight=0.604
```

```
number_of_fold = 5
skf = StratifiedKFold(n_splits=number_of_fold, shuffle=True, random_state=42)
print("OK: CV ready")
```

```
OK: CV ready
```

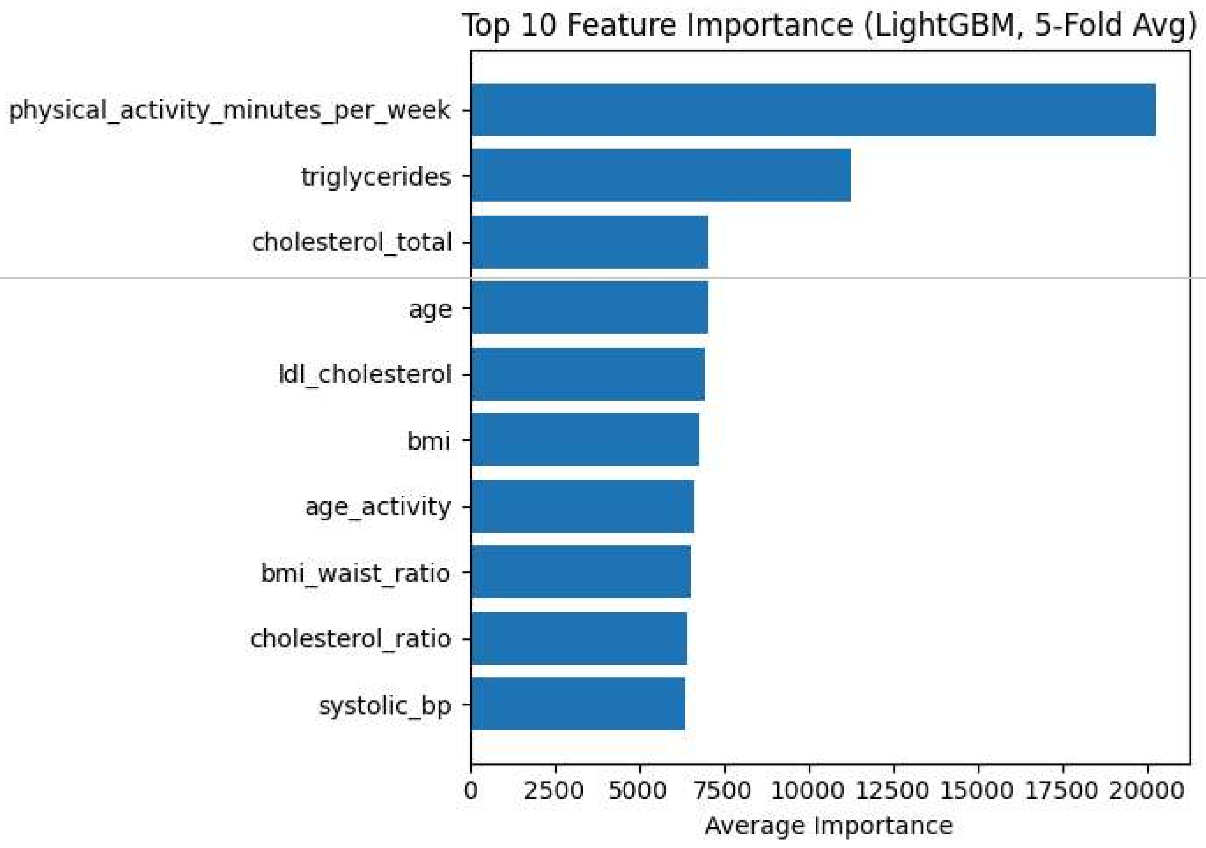
```
xgb_fold_aucs = []
xgboost_val_pred = np.zeros(len(train))
xgboost_test_pred = np.zeros(len(test))

xgboost_params = dict(
        n_estimators=2500,
        learning_rate=0.02,
        max_depth=6,
        subsample=0.7,
        colsample_bytree=0.7,
        eval_metric="auc",
        tree_method="hist",
        random_state=42,
        scale_pos_weight=scale_pos_weight,
        n_jobs=-1,
        device="cuda",
)

print("\n================ XGBoost ================")
for fold_index, (train_index, valid_index) in enumerate(skf.split(X, y), 1):
        print(f"[XGBoost] {fold_index} / {number_of_fold}")

        X_train_fold, X_valid_fold = X[train_index], X[valid_index]
        y_train_fold, y_valid_fold = y[train_index], y[valid_index]

        model = xgb.XGBClassifier(**xgboost_params)
        model.fit(X_train_fold, y_train_fold, eval_set=[(X_valid_fold, y_valid_fold)], verbose=Fals

        val_pred = model.predict_proba(X_valid_fold)[:, 1]
        xgboost_val_pred[valid_index] = val_pred
        fold_auc = roc_auc_score(y_valid_fold, val_pred)
        xgb_fold_aucs.append(fold_auc)
        print(f"    AUC: {fold_auc:.5f}")

        xgboost_test_pred += model.predict_proba(X_test)[:, 1] / number_of_fold

xgboost_overall_auc = roc_auc_score(y, xgboost_val_pred)
print(f"\n[XGBoost] Overall AUC: {xgboost_overall_auc:.5f}")
print(f"[XGBoost] Mean Fold AUC: {np.mean(xgb_fold_aucs):.5f} (+/- {np.std(xgb_fold_aucs):.5f})")
```

```
================ XGBoost ================
[XGBoost] 1 / 5
  AUC: 0.72659
[XGBoost] 2 / 5
  AUC: 0.72537
[XGBoost] 3 / 5
  AUC: 0.72564
[XGBoost] 4 / 5
  AUC: 0.72740
[XGBoost] 5 / 5
  AUC: 0.72645

[XGBoost] Overall AUC: 0.72629
[XGBoost] Mean Fold AUC: 0.72629 (+/- 0.00072)
```

```
lgb_fold_aucs = []
lightgbm_val_pred = np.zeros(len(train))
lightgbm_test_pred = np.zeros(len(test))

lgb_importance_sum = np.zeros(len(feature_names))

lightgbm_params = dict(
        objective="binary",
        boosting_type="gbdt",
        learning_rate=0.015,
        n_estimators=8000,
        num_leaves=24,
        max_depth=-1,
        min_data_in_leaf=150,
        subsample=0.7,
        colsample_bytree=0.6,
        reg_lambda=6.0,
        reg_alpha=2.0,
        random_state=42,
        n_jobs=-1,
        scale_pos_weight=scale_pos_weight,
        device="gpu",
)

print("\n================ LightGBM ================")
for fold_index, (train_index, valid_index) in enumerate(skf.split(X, y), 1):
        print(f"[LightGBM] {fold_index} / {number_of_fold}")

        X_train_fold, X_valid_fold = X[train_index], X[valid_index]
        y_train_fold, y_valid_fold = y[train_index], y[valid_index]

        model = lgb.LGBMClassifier(**lightgbm_params)
        model.fit(
                X_train_fold, y_train_fold,
                eval_set=[(X_valid_fold, y_valid_fold)],
                eval_metric="auc",
                callbacks=[lgb.early_stopping(200, verbose=False)],
        )

        val_pred = model.predict_proba(X_valid_fold, num_iteration=model.best_iteration_)[:, 1]
        lightgbm_val_pred[valid_index] = val_pred

        fold_auc = roc_auc_score(y_valid_fold, val_pred)
        lgb_fold_aucs.append(fold_auc)
        print(f"    AUC: {fold_auc:.5f}")

        lightgbm_test_pred += model.predict_proba(X_test, num_iteration=model.best_iteration_)[:, 1

        lgb_importance_sum += model.feature_importances_

    lightgbm_overall_auc = roc_auc_score(y, lightgbm_val_pred)
    print(f"\n[LightGBM] Overall AUC: {lightgbm_overall_auc:.5f}")
    print(f"[LightGBM] Mean Fold AUC: {np.mean(lgb_fold_aucs):.5f} (+/- {np.std(lgb_fold_aucs):.5f})"


    lgb_importance_avg = lgb_importance_sum / number_of_fold
    fi = pd.DataFrame({"feature": feature_names, "importance": lgb_importance_avg}) \
           .sort_values("importance", ascending=False).head(10)

    plt.figure(figsize=(7,5))
    plt.barh(fi["feature"], fi["importance"])
    plt.gca().invert_yaxis()
    plt.xlabel("Average Importance")
    plt.title(f"Top 10 Feature Importance (LightGBM, {number_of_fold}-Fold Avg)")
    plt.tight_layout()
    plt.savefig("lgb_feature_importance.png", dpi=300, bbox_inches="tight")
    plt.show()

    fi
```

```
================ LightGBM ================
[LightGBM] 1 / 5
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] Number of positive: 349045, number of negative: 210955
[LightGBM] [Info] This is the GPU trainer!!
[LightGBM] [Info] Total Bins 2838
[LightGBM] [Info] Number of data points in the train set: 560000, number of used features: 49
[LightGBM] [Info] Using GPU Device: NVIDIA A100-SXM4-40GB, Vendor: NVIDIA Corporation
[LightGBM] [Info] Compiling OpenCL Kernel with 256 bins...
[LightGBM] [Info] GPU programs have been built
[LightGBM] [Info] Size of histogram bin entry: 8
[LightGBM] [Info] 26 dense feature groups (14.95 MB) transferred to GPU in 0.013547 secs. 1 s
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.623295 -> initscore=0.503556
[LightGBM] [Info] Start training from score 0.503556
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
  AUC: 0.72861
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] 2 / 5
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] Number of positive: 349045, number of negative: 210955
[LightGBM] [Info] This is the GPU trainer!!
[LightGBM] [Info] Total Bins 2842
[LightGBM] [Info] Number of data points in the train set: 560000, number of used features: 49
[LightGBM] [Info] Using GPU Device: NVIDIA A100-SXM4-40GB, Vendor: NVIDIA Corporation
[LightGBM] [Info] Compiling OpenCL Kernel with 256 bins...
[LightGBM] [Info] GPU programs have been built
[LightGBM] [Info] Size of histogram bin entry: 8
[LightGBM] [Info] 26 dense feature groups (14.95 MB) transferred to GPU in 0.013252 secs. 1 s
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.623295 -> initscore=0.503556
[LightGBM] [Info] Start training from score 0.503556
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
  AUC: 0.72726
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] 3 / 5
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] Number of positive: 349046, number of negative: 210954
[LightGBM] [Info] This is the GPU trainer!!
[LightGBM] [Info] Total Bins 2843
[LightGBM] [Info] Number of data points in the train set: 560000, number of used features: 49
[LightGBM] [Info] Using GPU Device: NVIDIA A100-SXM4-40GB, Vendor: NVIDIA Corporation
[LightGBM] [Info] Compiling OpenCL Kernel with 256 bins...
[LightGBM] [Info] GPU programs have been built
[LightGBM] [Info] Size of histogram bin entry: 8
[LightGBM] [Info] 26 dense feature groups (14.95 MB) transferred to GPU in 0.013856 secs. 1 s
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.623296 -> initscore=0.503564
[LightGBM] [Info] Start training from score 0.503564
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
  AUC: 0.72791
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] 4 / 5
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] Number of positive: 349046, number of negative: 210954
[LightGBM] [Info] This is the GPU trainer!!
[LightGBM] [Info] Total Bins 2839
[LightGBM] [Info] Number of data points in the train set: 560000, number of used features: 49
[LightGBM] [Info] Using GPU Device: NVIDIA A100-SXM4-40GB, Vendor: NVIDIA Corporation
```

```
[LightGBM] [Info] Compiling OpenCL Kernel with 256 bins...
[LightGBM] [Info] GPU programs have been built
[LightGBM] [Info] Size of histogram bin entry: 8
[LightGBM] [Info] 26 dense feature groups (14.95 MB) transferred to GPU in 0.013554 secs. 1 s
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.623296 -> initscore=0.503564
[LightGBM] [Info] Start training from score 0.503564
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
  AUC: 0.72918
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] 5 / 5
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] Number of positive: 349046, number of negative: 210954
[LightGBM] [Info] This is the GPU trainer!!
[LightGBM] [Info] Total Bins 2840
[LightGBM] [Info] Number of data points in the train set: 560000, number of used features: 49
[LightGBM] [Info] Using GPU Device: NVIDIA A100-SXM4-40GB, Vendor: NVIDIA Corporation
[LightGBM] [Info] Compiling OpenCL Kernel with 256 bins...
[LightGBM] [Info] GPU programs have been built
[LightGBM] [Info] Size of histogram bin entry: 8
[LightGBM] [Info] 26 dense feature groups (14.95 MB) transferred to GPU in 0.013493 secs. 1 s
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.623296 -> initscore=0.503564
[LightGBM] [Info] Start training from score 0.503564
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre
  AUC: 0.72900
[LightGBM] [Warning] min_data_in_leaf is set=150, min_child_samples=20 will be ignored. Curre

[LightGBM] Overall AUC: 0.72839
[LightGBM] Mean Fold AUC: 0.72839 (+/- 0.00071)
```

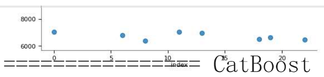


1 to 10 of 10 entries Filter

index	feature	importance
2	physical_activity_minutes_per_week	20252.8
14	triglycerides	11241.6

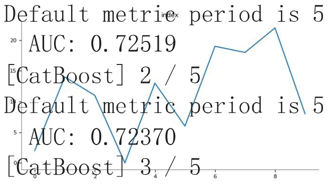
后续步骤： 使用 fi 生成代码 New interactive sheet

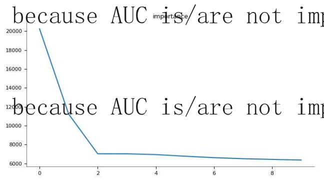
```python
cat_fold_aucs = []
catboost_val_pred = np.zeros(len(train))
catboost_test_pred = np.zeros(len(test))

cat_params = dict(
        iterations=5000,
        learning_rate=0.02,
        depth=6,
        loss_function="Logloss",
        eval_metric="AUC",
        random_seed=42,
        verbose=False,
        task_type="GPU",
)

print("\n================ CatBoost ================")
for fold_index, (train_index, valid_index) in enumerate(skf.split(X, y), 1):
        print(f"[CatBoost] {fold_index} / {number_of_fold}")

        X_train_fold, X_valid_fold = X[train_index], X[valid_index]
        y_train_fold, y_valid_fold = y[train_index], y[valid_index]

        model = CatBoostClassifier(**cat_params)
        model.fit(
                X_train_fold, y_train_fold,
                eval_set=(X_valid_fold, y_valid_fold),
                early_stopping_rounds=100,
                verbose=False,
        )

        val_pred = model.predict_proba(X_valid_fold)[:, 1]
        catboost_val_pred[valid_index] = val_pred

        fold_auc = roc_auc_score(y_valid_fold, val_pred)
        cat_fold_aucs.append(fold_auc)
        print(f"    AUC: {fold_auc:.5f}")

        catboost_test_pred += model.predict_proba(X_test)[:, 1] / number_of_fold

catboost_overall_auc = roc_auc_score(y, catboost_val_pred)
print(f"\n[CatBoost] Overall AUC: {catboost_overall_auc:.5f}")
print(f"[CatBoost] Mean Fold AUC: {np.mean(cat_fold_aucs):.5f} (+/- {np.std(cat_fold_aucs):.5f})"
```



```
================ CatBoost ================
[CatBoost] 1 / 5
Default metric period is 5 because AUC is/are not implemented for GPU
  AUC: 0.72519
[CatBoost] 2 / 5
Default metric period is 5 because AUC is/are not implemented for GPU
  AUC: 0.72370
[CatBoost] 3 / 5
Default metric period is 5 because AUC is/are not implemented for GPU
  AUC: 0.72453
[CatBoost] 4 / 5
Default metric period is 5 because AUC is/are not implemented for GPU
  AUC: 0.72569
```

Values





```
[CatBoost] 5 / 5
Default metric period is 5 because AUC is/are not implemented for GPU
  AUC: 0.72520

[CatBoost] Overall AUC: 0.72485
[CatBoost] Mean Fold AUC: 0.72486 (+/- 0.00069)
```

```
best_auc = -1
best_weights = None

for wx in np.arange(0, 1.01, 0.1):
    for wl in np.arange(0, 1.01 - wx, 0.1):
        wc = 1 - wx - wl
        blended = wx*xgboost_val_pred + wl*lightgbm_val_pred + wc*catboost_val_pred
        score = roc_auc_score(y, blended)
        if score > best_auc:
            best_auc = score
            best_weights = (wx, wl, wc)

wx, wl, wc = best_weights
ensemble_val_pred = wx*xgboost_val_pred + wl*lightgbm_val_pred + wc*catboost_val_pred
ensemble_auc = roc_auc_score(y, ensemble_val_pred)

ensemble_test_pred = wx*xgboost_test_pred + wl*lightgbm_test_pred + wc*catboost_test_pred

print("Best weights (XGB, LGBM, CAT):", best_weights)
print("Best ensemble AUC:", f"{ensemble_auc:.5f}")

results_df = pd.DataFrame({
    "Model": ["XGBoost", "LightGBM", "CatBoost", "Ensemble"],
    "CV ROC-AUC (OOF)": [xgboost_overall_auc, lightgbm_overall_auc, catboost_overall_auc, ens
    "Mean Fold AUC": [np.mean(xgb_fold_aucs), np.mean(lgb_fold_aucs), np.mean(cat_fold_aucs),
    "Std Fold AUC": [np.std(xgb_fold_aucs), np.std(lgb_fold_aucs), np.std(cat_fold_aucs), np.
})
results_df
```

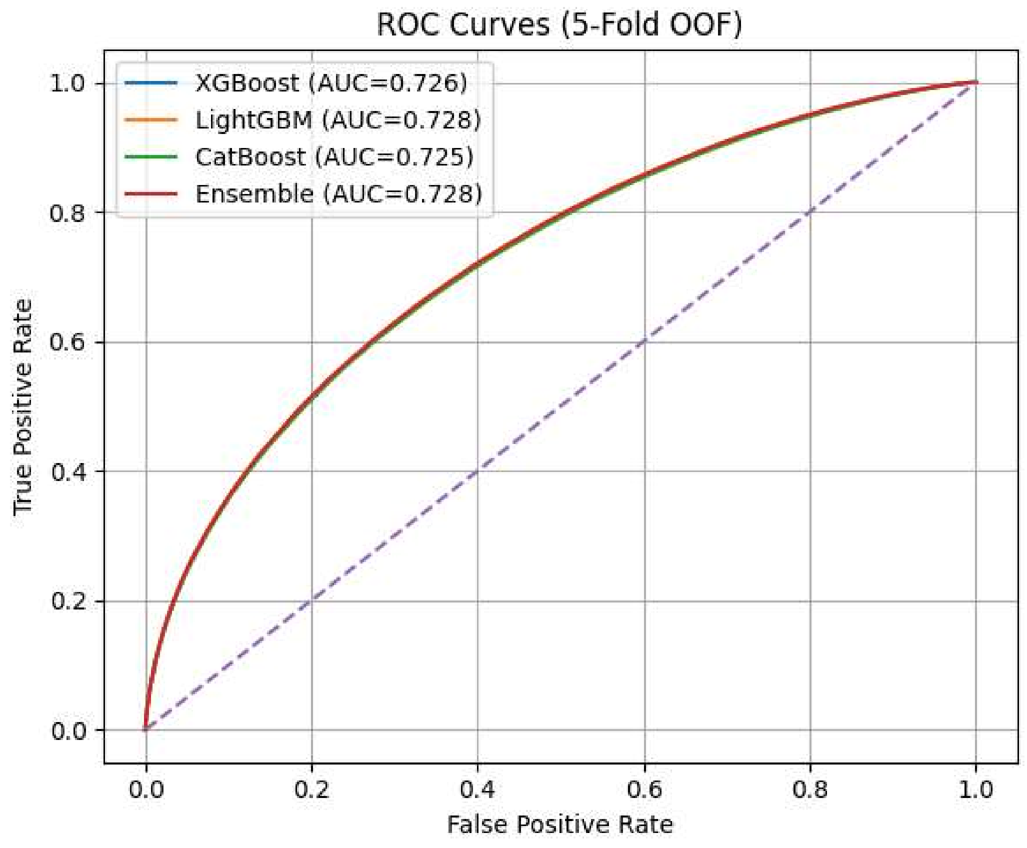
```
Best weights (XGB, LGBM, CAT): (np.float64(0.0), np.float64(1.0), np.float64(0.0))
Best ensemble AUC: 0.72839
```

	Model	CV ROC-AUC (OOF)	Mean Fold AUC	Std Fold AUC
0	XGBoost	0.726289	0.726290	0.000725
1	LightGBM	0.728390	0.728392	0.000713
2	CatBoost	0.724855	0.724861	0.000688
3	Ensemble	0.728390	NaN	NaN

后续步骤： 使用 results_df 生成代码 New interactive sheet

```
plt.figure(figsize=(6,5))
for name, pred in [
    ("XGBoost", xgboost_val_pred),
    ("LightGBM", lightgbm_val_pred),
    ("CatBoost", catboost_val_pred),
    ("Ensemble", ensemble_val_pred),
]:
    fpr, tpr, _ = roc_curve(y, pred)
```

```
        roc_auc_val = auc(fpr, tpr)
        plt.plot(fpr, tpr, label=f"{name} (AUC={roc_auc_val:.3f})")

plt.plot([0,1],[0,1], linestyle="--")
plt.xlabel("False Positive Rate")
plt.ylabel("True Positive Rate")
plt.title(f"ROC Curves ({number_of_fold}-Fold OOF)")
plt.legend()
plt.grid(True)
plt.tight_layout()
plt.savefig("roc_curves.png", dpi=300, bbox_inches="tight")
plt.show()

print("saved: roc_curves.png")
```



```
saved: roc_curves.png
```

```
submission = sample_sub.copy()
submission[target] = ensemble_test_pred
submission.to_csv("submission_final.csv", index=False)

print("saved: submission_final.csv")
print("saved: lgb_feature_importance.png")
```