Model Persistence: Save, Load, and Deploy

Why Model Persistence?

```
WHY SAVE MODELS?

1. REPRODUCIBILITY
   - Same predictions every time
   - Audit trail for compliance
   - Version control models

2. DEPLOYMENT
   - Train once, predict many times
   - No need to re-fit on server
   - Faster predictions

3. SHARING
   - Share models with team
   - Model registry (MLflow)
   - API serving

COMMON FORMATS:

pickle / joblib
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+ Fast, easy
+ Works with sklearn
- Python version sensitive
- Security risk (arbitrary code)

ONNX
----
+ Framework agnostic
+ Production-ready
- More complex setup

JSON (coefficients only)
------------------------
+ Human readable
+ Framework agnostic
- Manual reconstruction
```
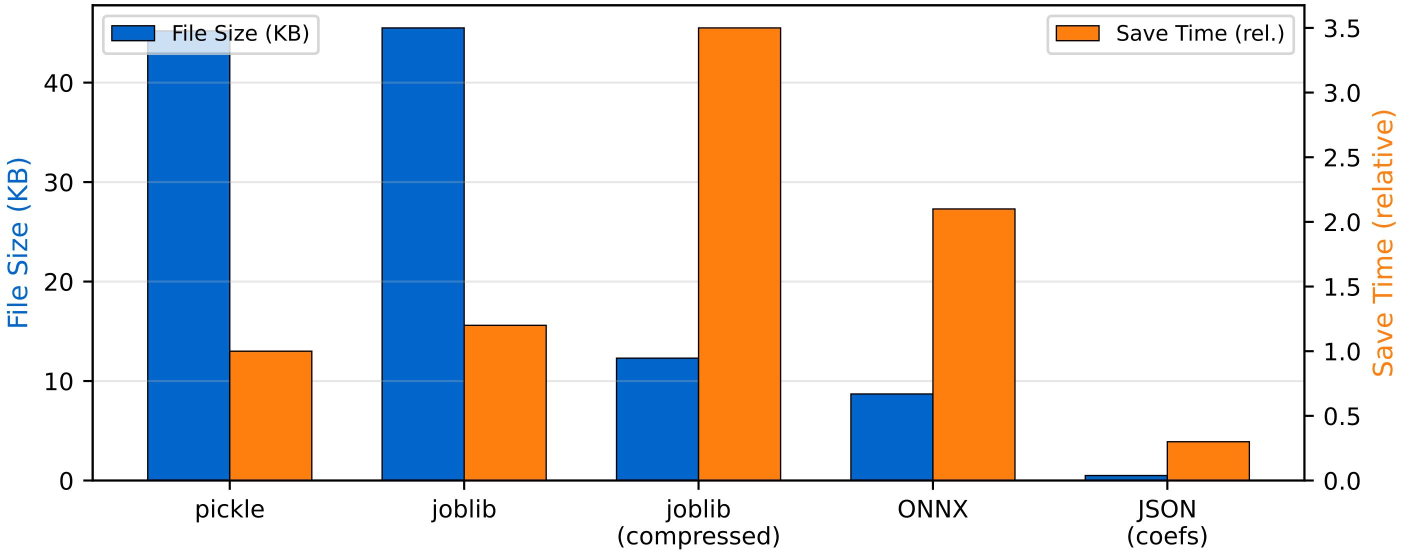

Storage Format Comparison



pickle & joblib Code

```
Saving and Loading sklearn Models

import pickle
import joblib
from sklearn.linear_model import Ridge

# ===================
# METHOD 1: pickle
# ===================
# Save
with open('model.pkl', 'wb') as f:
    pickle.dump(model, f)

# Load
with open('model.pkl', 'rb') as f:
    loaded_model = pickle.load(f)

# ===================
# METHOD 2: joblib (recommended for sklearn)
# ===================
# Save (uncompressed)
joblib.dump(model, 'model.joblib')

# Save (compressed - smaller file)
joblib.dump(model, 'model.joblib.gz', compress=3)

# Load
loaded_model = joblib.load('model.joblib')

# ===================
# Use loaded model
# ===================
predictions = loaded_model.predict(X_new)

# Verify it's the same
assert np.allclose(model.coef_, loaded_model.coef_)
```

Best Practices

```
MODEL PERSISTENCE BEST PRACTICES

1. VERSION EVERYTHING
   model_v1.0.0_2024-01-15.joblib
   - Include version number
   - Include training date
   - Track with git/DVC

2. SAVE METADATA
   {
     "model_type": "Ridge",
     "features": ["MKT", "SMB", "HML"],
     "train_r2": 0.73,
     "train_date": "2024-01-15",
     "sklearn_version": "1.3.0",
     "python_version": "3.10.12"
   }

3. SAVE PREPROCESSING TOO
   - StandardScaler parameters
   - Feature names and order
   - Or use Pipeline (saves everything)

4. SECURITY
   - Never load untrusted pickles!
   - Pickle can execute arbitrary code
   - Use joblib with trusted sources only

5. TESTING
   # After loading:
   assert model.feature_names_in_ == expected_features
   assert model.predict(X_test[:1]).shape == (1,)
```