

CNC機台銑刀磨損偵測

使用版本: PyCaret 2.2.1

1.0 學習目標

本課程使用 "pycaret.classification" 模組來進行二元分類。 使用CNC機台銑刀磨損(CNC Mill Tool Wear)資料集。

將使用以下流程獲取資料、訓練模型與模型預測

A. 初始化

- 獲取分析資料：使用pandas函式庫讀取檔案。
- 設置實驗環境：在PyCaret中設置實驗用以開始構建分類模型。

B. 訓練模型

- 建構模型：建構模型，執行分層交叉驗證和評估分類指標。
- 調整模型：自動調整分類模型的超參數。

C. 模型分析

- 分析模型性能：使用各種圖形分析模型性能。

D. 模型運用

- 部署模型確定：在實驗結束時最終確定最佳模型。
- 模型預測：對未知的資料進行預測。

1.1 安裝 PyCaret 函式庫

```
!pip install pycaret
```

1.2 Pre-Requisites

- Python 3.6 或更新版本
- PyCaret 2.2.1 或更新版本
- 二元分類的基礎知識

1.3 For Google colab users:

若是要在 Google colab 執行，可使用下列程式碼開啟 notebook 圖形互動功能。

```
from pycaret.utils import enable_colab  
enable_colab()
```

In [1]:

```
!pip install pycaret
```

```
Collecting pycaret
```

```
  Downloading https://files.pythonhosted.org/packages/33/4d/792832e86c34eb7f8c06f1805f19ef72a2d38b11435502b69fca3409b84c/pycaret-2.2.2-py3-none-any.whl (249kB)
```

```
 |██████████| 256kB 5.8MB/s
```

```
Collecting xgboost>=1.1.0
```

```
  Downloading https://files.pythonhosted.org/packages/35/cc/fd3d5fc6b661a03385a0f6492cc77a253940d1026406ecc07597095e381/xgboost-1.2.1-py3-none-manylinux2010_x86_64.whl (148.9MB)
```

```
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```

```
Collecting mlflow
```

```
  Downloading https://files.pythonhosted.org/packages/b6/69/c6b3911ccb421adc779390ca2ea54cb888a54e282d50e8d20ce751b5c7ab/mlflow-1.12.1-py3-none-any.whl (13.9MB)
```

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```

```
Requirement already satisfied: umap-learn in /usr/local/lib/python3.6/dist-packages (from pycaret) (0.4.6)
```

```
Requirement already satisfied: gensim in /usr/local/lib/python3.6/dist-packages (from pycaret) (3.6.0)
```

```
Requirement already satisfied: textblob in /usr/local/lib/python3.6/dist-packages (from pycaret) (0.15.3)
```

```
Requirement already satisfied: mlxtend in /usr/local/lib/python3.6/dist-packages (from pycaret) (0.14.0)
```

```
Collecting kmodes>=0.10.1
```

```
  Downloading https://files.pythonhosted.org/packages/b2/55/d8ec1ae1f7e1e02a8a4184c6852a3ee993b202b0459672c699d0ac18fc8/kmodes-0.10.2-py2.py3-none-any.whl
```

```
Requirement already satisfied: plotly>=4.4.1 in /usr/local/lib/python3.6/dist-packages (from pycaret) (4.4.1)
```

```
Collecting catboost>=0.23.2
```

```
  Downloading https://files.pythonhosted.org/packages/7e/c1/c1c4707013f9e2f8a96899dd3a87f66c9167d6d776a6dc8fe7ec8678d446/catboost-0.24.3-cp36-none-manylinux1_x86_64.whl (66.3MB)
```

```
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```

```
Requirement already satisfied: joblib in /usr/local/lib/python3.6/dist-packages (from pycaret) (0.17.0)
```

```
Requirement already satisfied: IPython in /usr/local/lib/python3.6/dist-packages (from pycaret) (5.5.0)
```

```
Collecting lightgbm>=2.3.1
```

```
  Downloading https://files.pythonhosted.org/packages/d6/4d/99073804bd31f15678f24a79e96981dcbaa840bc9926fdf132e9638d51bb/lightgbm-3.1.0-py2.py3-none-manylinux1_x86_64.whl (1.8MB)
```

```
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```

```
Collecting scikit-plot
```

```
  Downloading https://files.pythonhosted.org/packages/7c/47/32520e259340c140a4ad27c1b97050dd3254fdc517b1d59974d47037510e/scikit_plot-0.3.7-py3-none-any.whl
```

```
Requirement already satisfied: numpy>=1.17 in /usr/local/lib/python3.6/dist-packages (from pycaret) (1.18.5)
```

```
Requirement already satisfied: seaborn in /usr/local/lib/python3.6/dist-packages (from pycaret) (0.11.0)
```

```
Requirement already satisfied: pandas in /usr/local/lib/python3.6/dist-packages (from pycaret) (1.1.4)
```

```
Collecting imbalanced-learn>=0.7.0
```

```
  Downloading https://files.pythonhosted.org/packages/c8/81/8db4d87b03b998fda7c6f835d807c9ae4e3b141f978597b8d7f31600be15/imbalanced_learn-0.7.0-py3-none-any.whl (167kB)
```

```
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```

```
Requirement already satisfied: wordcloud in /usr/local/lib/python3.6/dist-packages (from pycaret) (1.5.0)
```

```
Collecting yellowbrick>=1.0.1
```

```
    Downloading https://files.pythonhosted.org/packages/1f/ad/ae6744ddb9c705
3916bed95430152b9a41b7d410e16a1cc7cd744a611d90/yellowbrick-1.2-py3-none-an
y.whl (269kB)
|██████████| 276kB 40.8MB/s
Requirement already satisfied: nltk in /usr/local/lib/python3.6/dist-pac
kages (from pycaret) (3.2.5)
Requirement already satisfied: spacy in /usr/local/lib/python3.6/dist-pac
kages (from pycaret) (2.2.4)
Requirement already satisfied: ipywidgets in /usr/local/lib/python3.6/dist
-packages (from pycaret) (7.5.1)
Collecting pandas-profiling>=2.8.0
    Downloading https://files.pythonhosted.org/packages/32/79/5d03ed1172e3e6
7a997a6a795bcd2ab58f84851969d01a91455383795b6/pandas_profiling-2.9.0-py2.
py3-none-any.whl (258kB)
|██████████| 266kB 46.6MB/s
Requirement already satisfied: cufflinks>=0.17.0 in /usr/local/lib/python
3.6/dist-packages (from pycaret) (0.17.3)
Requirement already satisfied: matplotlib in /usr/local/lib/python3.6/dist
-packages (from pycaret) (3.2.2)
Collecting scikit-learn>=0.23.2
    Downloading https://files.pythonhosted.org/packages/5c/a1/273def87037a7f
b010512bbc5901c31cfddfc8080bc63b42b26e3cc55b3/scikit_learn-0.23.2-cp36-cp
36m-manylinux1_x86_64.whl (6.8MB)
|██████████| 6.8MB 46.6MB/s
Collecting pyod
    Downloading https://files.pythonhosted.org/packages/2b/1d/22a6c4e796fff1
066bf80bf59b4494d6e3582e22012a61721f4cb730b3c3/pyod-0.8.4.tar.gz (98kB)
|██████████| 102kB 11.6MB/s
Collecting pyLDAvis
    Downloading https://files.pythonhosted.org/packages/a5/3a/af82e070a8a96e
13217c8f362f9a73e82d61ac8fff3a2561946a97f96266/pyLDAvis-2.1.2.tar.gz (1.6M
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Requirement already satisfied: scipy in /usr/local/lib/python3.6/dist-pac
kages (from xgboost>=1.1.0->pycaret) (1.4.1)
Requirement already satisfied: click>=7.0 in /usr/local/lib/python3.6/dist
-packages (from mlflow->pycaret) (7.1.2)
Collecting azure-storage-blob
    Downloading https://files.pythonhosted.org/packages/e7/5d/0bb4ed37da2523
c393789b1d8ecbf56b1d35fa344af30fe423da2c06cbe9/azure_storage_blob-12.6.0-p
y2.py3-none-any.whl (328kB)
|██████████| 337kB 43.6MB/s
Requirement already satisfied: entrypoints in /usr/local/lib/python3.6/dis
t-packages (from mlflow->pycaret) (0.3)
Collecting gitpython>=2.1.0
    Downloading https://files.pythonhosted.org/packages/24/d1/a7f8fe3df25854
9b303415157328bfcc63e9b11d06a7ad7a3327f3d32606/GitPython-3.1.11-py3-none-a
ny.whl (159kB)
|██████████| 163kB 49.9MB/s
Requirement already satisfied: sqlalchemy in /usr/local/lib/python3.6/dist
-packages (from mlflow->pycaret) (1.3.20)
Requirement already satisfied: requests>=2.17.3 in /usr/local/lib/python3.
6/dist-packages (from mlflow->pycaret) (2.23.0)
Collecting alembic<=1.4.1
    Downloading https://files.pythonhosted.org/packages/e0/e9/359dbb77c35c41
9df0aedeb1d53e71e7e3f438ff64a8fdb048c907404de3/alembic-1.4.1.tar.gz (1.1M
B)
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Requirement already satisfied: six>=1.10.0 in /usr/local/lib/python3.6/dis
t-packages (from mlflow->pycaret) (1.15.0)
Requirement already satisfied: sqlparse>=0.3.1 in /usr/local/lib/python3.
```

```
6/dist-packages (from mlflow->pycaret) (0.4.1)
Collecting prometheus-flask-exporter
  Downloading https://files.pythonhosted.org/packages/4c/d5/8a046d683c2cc0
  84b6a502812827ede69b1064f95d93f94b83f809b21723/prometheus_flask_exporter-
  0.18.1.tar.gz
Requirement already satisfied: protobuf>=3.6.0 in /usr/local/lib/python3.
6/dist-packages (from mlflow->pycaret) (3.12.4)
Collecting databricks-cli>=0.8.7
  Downloading https://files.pythonhosted.org/packages/40/88/ae1f78cf582b70
  7c605c77df49b4c8786a4465edc51adb25d2f98ef4c4de/databricks-cli-0.14.1.tar.g
  z (54kB)
|██████████| 61kB 8.7MB/s
Requirement already satisfied: pyyaml in /usr/local/lib/python3.6/dist-pac
kages (from mlflow->pycaret) (3.13)
Requirement already satisfied: cloudpickle in /usr/local/lib/python3.6/dis
t-packages (from mlflow->pycaret) (1.3.0)
Collecting querystring-parser
  Downloading https://files.pythonhosted.org/packages/88/6b/572b2590fd5511
  4118bf08bde63c0a421dcc82d593700f3e2ad89908a8a9/querystring_parser-1.2.4-py
  2.py3-none-any.whl
Collecting gunicorn; platform_system != "Windows"
  Downloading https://files.pythonhosted.org/packages/69/ca/926f7cd3a2014b
  16870086b2d0fdc84a9e49473c68a8dff8b57f7c156f43/gunicorn-20.0.4-py2.py3-non
  e-any.whl (77kB)
|██████████| 81kB 10.7MB/s
Collecting docker>=4.0.0
  Downloading https://files.pythonhosted.org/packages/ef/b7/eb7b7138bb5e6d
  28cf84fa586fe594619ca097b6207caa5f2ebe0c66a4ed/docker-4.4.0-py2.py3-none-a
  ny.whl (146kB)
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Requirement already satisfied: Flask in /usr/local/lib/python3.6/dist-pack
ages (from mlflow->pycaret) (1.1.2)
Requirement already satisfied: python-dateutil in /usr/local/lib/python3.
6/dist-packages (from mlflow->pycaret) (2.8.1)
Requirement already satisfied: numba!=0.47,>=0.46 in /usr/local/lib/python
3.6/dist-packages (from umap-learn->pycaret) (0.48.0)
Requirement already satisfied: smart-open>=1.2.1 in /usr/local/lib/python
3.6/dist-packages (from gensim->pycaret) (3.0.0)
Requirement already satisfied: setuptools in /usr/local/lib/python3.6/dist
-packages (from mlxtend->pycaret) (50.3.2)
Requirement already satisfied: retrying>=1.3.3 in /usr/local/lib/python3.
6/dist-packages (from plotly>=4.4.1->pycaret) (1.3.3)
Requirement already satisfied: graphviz in /usr/local/lib/python3.6/dist-p
ackages (from catboost>=0.23.2->pycaret) (0.10.1)
Requirement already satisfied: decorator in /usr/local/lib/python3.6/dist-
packages (from IPython->pycaret) (4.4.2)
Requirement already satisfied: pexpect; sys_platform != "win32" in /usr/lo
cal/lib/python3.6/dist-packages (from IPython->pycaret) (4.8.0)
Requirement already satisfied: simplegeneric>0.8 in /usr/local/lib/python
3.6/dist-packages (from IPython->pycaret) (0.8.1)
Requirement already satisfied: pygments in /usr/local/lib/python3.6/dist-p
ackages (from IPython->pycaret) (2.6.1)
Requirement already satisfied: prompt-toolkit<2.0.0,>=1.0.4 in /usr/local/
lib/python3.6/dist-packages (from IPython->pycaret) (1.0.18)
Requirement already satisfied: pickleshare in /usr/local/lib/python3.6/dis
t-packages (from IPython->pycaret) (0.7.5)
Requirement already satisfied: traitlets>=4.2 in /usr/local/lib/python3.6/
dist-packages (from IPython->pycaret) (4.3.3)
Requirement already satisfied: pytz>=2017.2 in /usr/local/lib/python3.6/di
st-packages (from pandas->pycaret) (2018.9)
Requirement already satisfied: pillow in /usr/local/lib/python3.6/dist-pac
```

```
kages (from wordcloud->pycaret) (7.0.0)
Requirement already satisfied: cycler>=0.10.0 in /usr/local/lib/python3.6/dist-packages (from yellowbrick>=1.0.1->pycaret) (0.10.0)
Requirement already satisfied: plac<1.2.0,>=0.9.6 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (1.1.3)
Requirement already satisfied: srsly<1.1.0,>=1.0.2 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (1.0.4)
Requirement already satisfied: wasabi<1.1.0,>=0.4.0 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (0.8.0)
Requirement already satisfied: thinc==7.4.0 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (7.4.0)
Requirement already satisfied: cymem<2.1.0,>=2.0.2 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (2.0.4)
Requirement already satisfied: murmurhash<1.1.0,>=0.28.0 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (1.0.4)
Requirement already satisfied: blis<0.5.0,>=0.4.0 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (0.4.1)
Requirement already satisfied: catalogue<1.1.0,>=0.0.7 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (1.0.0)
Requirement already satisfied: preshed<3.1.0,>=3.0.2 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (3.0.4)
Requirement already satisfied: tqdm<5.0.0,>=4.38.0 in /usr/local/lib/python3.6/dist-packages (from spacy->pycaret) (4.41.1)
Requirement already satisfied: nbformat>=4.2.0 in /usr/local/lib/python3.6/dist-packages (from ipywidgets->pycaret) (5.0.8)
Requirement already satisfied: widgetsnbextension~=3.5.0 in /usr/local/lib/python3.6/dist-packages (from ipywidgets->pycaret) (3.5.1)
Requirement already satisfied: ipykernel>=4.5.1 in /usr/local/lib/python3.6/dist-packages (from ipywidgets->pycaret) (4.10.1)
Collecting tangled-up-in-unicode>=0.0.6
  Downloading https://files.pythonhosted.org/packages/4a/e2/e588ab9298d4989ce7fdb2b97d18aac878d99dbdc379a4476a09d9271b68/tangled_up_in_unicode-0.0.6-py3-none-any.whl (3.1MB)
    ██████████ | 3.1MB 41.3MB/s
Collecting htmlmin>=0.1.12
  Downloading https://files.pythonhosted.org/packages/b3/e7/fcd59e12169de19f0131ff2812077f964c6b960e7c09804d30a7bf2ab461/htmlmin-0.1.12.tar.gz
Collecting confuse>=1.0.0
  Downloading https://files.pythonhosted.org/packages/6d/55/b4726d81e5d6509fa3441f770f8a9524612627dc1b2a7d6209d1d20083fe/confuse-1.4.0-py3-none-any.whl
Requirement already satisfied: missingno>=0.4.2 in /usr/local/lib/python3.6/dist-packages (from pandas-profiling>=2.8.0->pycaret) (0.4.2)
Requirement already satisfied: jinja2>=2.11.1 in /usr/local/lib/python3.6/dist-packages (from pandas-profiling>=2.8.0->pycaret) (2.11.2)
Collecting phik>=0.9.10
  Downloading https://files.pythonhosted.org/packages/01/5a/7ef1c04ce62cd72f900c06298dc2385840550d5c653a0dbc19109a5477e6/phik-0.10.0-py3-none-any.whl (599kB)
    ██████████ | 604kB 41.0MB/s
Requirement already satisfied: attrs>=19.3.0 in /usr/local/lib/python3.6/dist-packages (from pandas-profiling>=2.8.0->pycaret) (20.3.0)
Collecting visions[type_image_path]==0.5.0
  Downloading https://files.pythonhosted.org/packages/26/e3/9416e94e767d59a86edcbcb8e1c8f42874d272c3b343676074879e9db0e0/visions-0.5.0-py3-none-any.whl (64kB)
    ██████████ | 71kB 9.3MB/s
Requirement already satisfied: colorlover>=0.2.1 in /usr/local/lib/python3.6/dist-packages (from cufflinks>=0.17.0->pycaret) (0.3.0)
Requirement already satisfied: pyparsing!=2.0.4,!>=2.1.2,!>=2.1.6,>=2.0.1 in /usr/local/lib/python3.6/dist-packages (from matplotlib->pycaret) (2.4.7)
```

```
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.6/dist-packages (from matplotlib->pycaret) (1.3.1)
Collecting threadpoolctl>=2.0.0
  Downloading https://files.pythonhosted.org/packages/f7/12/ec3f2e203afa394a149911729357aa48affc59c20e2c1c8297a60f33f133/threadpoolctl-2.1.0-py3-none-any.whl
Collecting combo
  Downloading https://files.pythonhosted.org/packages/0a/2a/61b6ac584e75d8df16dc27962aa5fe99d76b09da5b6710e83d4862c84001/combo-0.1.1.tar.gz
Requirement already satisfied: statsmodels in /usr/local/lib/python3.6/dist-packages (from pyod->pycaret) (0.10.2)
Collecting suod
  Downloading https://files.pythonhosted.org/packages/a1/87/9170cabef1b5e10a7d095c0e28f2e30e7c1886a13f063de85d3cfacc06f4b/suod-0.0.4.tar.gz (2.1MB)
|██████████| 2.1MB 40.6MB/s
Requirement already satisfied: wheel>=0.23.0 in /usr/local/lib/python3.6/dist-packages (from pyLDAvis->pycaret) (0.35.1)
Requirement already satisfied: numexpr in /usr/local/lib/python3.6/dist-packages (from pyLDAvis->pycaret) (2.7.1)
Requirement already satisfied: pytest in /usr/local/lib/python3.6/dist-packages (from pyLDAvis->pycaret) (3.6.4)
Requirement already satisfied: future in /usr/local/lib/python3.6/dist-packages (from pyLDAvis->pycaret) (0.16.0)
Collecting funcy
  Downloading https://files.pythonhosted.org/packages/66/89/479de0afbbfb98d1c4b887936808764627300208bb771fc823403645a36/funcy-1.15-py2.py3-none-any.whl
Collecting msrest>=0.6.10
  Downloading https://files.pythonhosted.org/packages/fa/f5/9e315fe8cb985b0ce052b34bcb767883dc739f46fadbf62f05a7e6d6eedbe/msrest-0.6.19-py2.py3-none-any.whl (84kB)
|██████████| 92kB 11.1MB/s
Collecting cryptography>=2.1.4
  Downloading https://files.pythonhosted.org/packages/4c/a2/6565c5271a79e3c96d7a079053b4d8408a740d4bf365f0f5f244a807bd09/cryptography-3.2.1-cp35-abi3-manylinux2010_x86_64.whl (2.6MB)
|██████████| 2.6MB 37.9MB/s
Collecting azure-core<2.0.0,>=1.9.0
  Downloading https://files.pythonhosted.org/packages/f8/4b/ea7faaaafac956a168ab9a95a7eb583f9d308e8332a68af0ed3128ef520c/azure_core-1.9.0-py2.py3-none-any.whl (124kB)
|██████████| 133kB 47.5MB/s
Collecting gitdb<5,>=4.0.1
  Downloading https://files.pythonhosted.org/packages/48/11/d1800bca0a3bae820b84b7d813ad1eff15a48a64cae9c823fc8c1b119e8/gitdb-4.0.5-py3-none-any.whl (63kB)
|██████████| 71kB 9.6MB/s
Requirement already satisfied: chardet<4,>=3.0.2 in /usr/local/lib/python3.6/dist-packages (from requests>=2.17.3->mlflow->pycaret) (3.0.4)
Requirement already satisfied: urllib3!=1.25.0,!~=1.25.1,<1.26,>=1.21.1 in /usr/local/lib/python3.6/dist-packages (from requests>=2.17.3->mlflow->pycaret) (1.24.3)
Requirement already satisfied: idna<3,>=2.5 in /usr/local/lib/python3.6/dist-packages (from requests>=2.17.3->mlflow->pycaret) (2.10)
Requirement already satisfied: certifi>=2017.4.17 in /usr/local/lib/python3.6/dist-packages (from requests>=2.17.3->mlflow->pycaret) (2020.11.8)
Collecting Mako
  Downloading https://files.pythonhosted.org/packages/a6/37/0e706200d22172eb8fa17d68a7ae22dec7631a0a92266634fb518a88a5b2/Mako-1.1.3-py2.py3-none-any.whl (75kB)
|██████████| 81kB 9.3MB/s
```

```
Collecting python-editor>=0.3
```

```
  Downloading https://files.pythonhosted.org/packages/c6/d3/201fc3abe391bb  
ae6606e6f1d598c15d367033332bd54352b12f35513717/python_editor-1.0.4-py3-non  
e-any.whl
```

```
Requirement already satisfied: prometheus_client in /usr/local/lib/python  
3.6/dist-packages (from prometheus-flask-exporter->mlflow->pycaret) (0.9.  
0)
```

```
Requirement already satisfied: tabulate>=0.7.7 in /usr/local/lib/python3.  
6/dist-packages (from databricks-cli>=0.8.7->mlflow->pycaret) (0.8.7)
```

```
Collecting websocket-client>=0.32.0
```

```
  Downloading https://files.pythonhosted.org/packages/4c/5f/f61b420143ed1c  
8dc69f9eaec5ff1ac36109d52c80de49d66e0c36c3dfdf/websocket_client-0.57.0-py  
2.py3-none-any.whl (200kB)
```

```
 |██████████| 204kB 47.7MB/s
```

```
Requirement already satisfied: Werkzeug>=0.15 in /usr/local/lib/python3.6/  
dist-packages (from Flask->mlflow->pycaret) (1.0.1)
```

```
Requirement already satisfied: itsdangerous>=0.24 in /usr/local/lib/python  
3.6/dist-packages (from Flask->mlflow->pycaret) (1.1.0)
```

```
Requirement already satisfied: llvmlite<0.32.0,>=0.31.0dev0 in /usr/local/  
lib/python3.6/dist-packages (from numba!=0.47,>=0.46->umap-learn->pycaret)  
(0.31.0)
```

```
Requirement already satisfied: ptyprocess>=0.5 in /usr/local/lib/python3.  
6/dist-packages (from pexpect; sys_platform != "win32"->IPython->pycaret)  
(0.6.0)
```

```
Requirement already satisfied: wcwidth in /usr/local/lib/python3.6/dist-pa  
ckages (from prompt-toolkit<2.0.0,>=1.0.4->IPython->pycaret) (0.2.5)
```

```
Requirement already satisfied: ipython-genutils in /usr/local/lib/python3.  
6/dist-packages (from traitlets>=4.2->IPython->pycaret) (0.2.0)
```

```
Requirement already satisfied: importlib-metadata>=0.20; python_version <  
"3.8" in /usr/local/lib/python3.6/dist-packages (from catalogue<1.1.0,>=0.  
0.7->spacy->pycaret) (2.0.0)
```

```
Requirement already satisfied: jsonschema!=2.5.0,>=2.4 in /usr/local/lib/p  
ython3.6/dist-packages (from nbformat>=4.2.0->ipywidgets->pycaret) (2.6.0)
```

```
Requirement already satisfied: jupyter-core in /usr/local/lib/python3.6/di  
st-packages (from nbformat>=4.2.0->ipywidgets->pycaret) (4.7.0)
```

```
Requirement already satisfied: notebook>=4.4.1 in /usr/local/lib/python3.  
6/dist-packages (from widgetsnbextension~=3.5.0->ipywidgets->pycaret) (5.  
3.1)
```

```
Requirement already satisfied: jupyter-client in /usr/local/lib/python3.6/  
dist-packages (from ipykernel>=4.5.1->ipywidgets->pycaret) (5.3.5)
```

```
Requirement already satisfied: tornado>=4.0 in /usr/local/lib/python3.6/di  
st-packages (from ipykernel>=4.5.1->ipywidgets->pycaret) (5.1.1)
```

```
Requirement already satisfied: MarkupSafe>=0.23 in /usr/local/lib/python3.  
6/dist-packages (from jinja2>=2.11.1->pandas-profiling>=2.8.0->pycaret)  
(1.1.1)
```

```
Requirement already satisfied: networkx>=2.4 in /usr/local/lib/python3.6/d  
ist-packages (from visions[type_image_path]==0.5.0->pandas-profiling>=2.8.  
0->pycaret) (2.5)
```

```
Collecting imagehash; extra == "type_image_path"
```

```
  Downloading https://files.pythonhosted.org/packages/8e/18/9dbb772b5ef73a  
3069c66bb5bf29b9fb4dd57af0d5790c781c3f559bcc6/ImageHash-4.2.0-py2.py3-non  
e-any.whl (295kB)
```

```
 |██████████| 296kB 43.2MB/s
```

```
Requirement already satisfied: patsy>=0.4.0 in /usr/local/lib/python3.6/di  
st-packages (from statsmodels->pyod->pycaret) (0.5.1)
```

```
Requirement already satisfied: pluggy<0.8,>=0.5 in /usr/local/lib/python3.  
6/dist-packages (from pytest->pyLDAvis->pycaret) (0.7.1)
```

```
Requirement already satisfied: py>=1.5.0 in /usr/local/lib/python3.6/dist-  
packages (from pytest->pyLDAvis->pycaret) (1.9.0)
```

```
Requirement already satisfied: more-itertools>=4.0.0 in /usr/local/lib/pyt  
hon3.6/dist-packages (from pytest->pyLDAvis->pycaret) (8.6.0)
```

```
Requirement already satisfied: atomicwrites>=1.0 in /usr/local/lib/python3.6/dist-packages (from pytest->pyLDAvis->pycaret) (1.4.0)
Requirement already satisfied: requests-oauthlib>=0.5.0 in /usr/local/lib/python3.6/dist-packages (from msrest>=0.6.10->azure-storage-blob->mlflow->pycaret) (1.3.0)
Collecting isodate>=0.6.0
  Downloading https://files.pythonhosted.org/packages/9b/9f/b36f7774ff5ea8e428fdcf4bb332c39ee5b9362ddd3d40d9516a55221b2/isodate-0.6.0-py2.py3-none-any.whl
    |████████| 51kB 7.6MB/s
Requirement already satisfied: cffi!=1.11.3,>=1.8 in /usr/local/lib/python3.6/dist-packages (from cryptography>=2.1.4->azure-storage-blob->mlflow->pycaret) (1.14.3)
Collecting smmap<4,>=3.0.1
  Downloading https://files.pythonhosted.org/packages/b0/9a/4d409a6234eb940e6a78dfdfc66156e7522262f5f2fecca07dc55915952d/smmap-3.0.4-py2.py3-none-any.whl
Requirement already satisfied: zipp>=0.5 in /usr/local/lib/python3.6/dist-packages (from importlib-metadata>=0.20; python_version < "3.8"->catalogue<1.1.0,>=0.0.7->spacy->pycaret) (3.4.0)
Requirement already satisfied: nbconvert in /usr/local/lib/python3.6/dist-packages (from notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (5.6.1)
Requirement already satisfied: terminado>=0.8.1 in /usr/local/lib/python3.6/dist-packages (from notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (0.9.1)
Requirement already satisfied: Send2Trash in /usr/local/lib/python3.6/dist-packages (from notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (1.5.0)
Requirement already satisfied: pyzmq>=13 in /usr/local/lib/python3.6/dist-packages (from jupyter-client->ipykernel>=4.5.1->ipywidgets->pycaret) (20.0.0)
Requirement already satisfied: PyWavelets in /usr/local/lib/python3.6/dist-packages (from imagehash; extra == "type_image_path"->visions[type_image_path]==0.5.0->pandas-profiling>=2.8.0->pycaret) (1.1.1)
Requirement already satisfied: oauthlib>=3.0.0 in /usr/local/lib/python3.6/dist-packages (from requests-oauthlib>=0.5.0->msrest>=0.6.10->azure-storage-blob->mlflow->pycaret) (3.1.0)
Requirement already satisfied: pyparser in /usr/local/lib/python3.6/dist-packages (from cffi!=1.11.3,>=1.8->cryptography>=2.1.4->azure-storage-blob->mlflow->pycaret) (2.20)
Requirement already satisfied: pandocfilters>=1.4.1 in /usr/local/lib/python3.6/dist-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (1.4.3)
Requirement already satisfied: bleach in /usr/local/lib/python3.6/dist-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (3.2.1)
Requirement already satisfied: testpath in /usr/local/lib/python3.6/dist-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (0.4.4)
Requirement already satisfied: defusedxml in /usr/local/lib/python3.6/dist-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (0.6.0)
Requirement already satisfied: mistune<2,>=0.8.1 in /usr/local/lib/python3.6/dist-packages (from nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (0.8.4)
Requirement already satisfied: packaging in /usr/local/lib/python3.6/dist-packages (from bleach->nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (20.4)
Requirement already satisfied: webencodings in /usr/local/lib/python3.6/dist-packages (from bleach->nbconvert->notebook>=4.4.1->widgetsnbextension~=3.5.0->ipywidgets->pycaret) (20.4)
```

```
3.5.0->ipywidgets->pycaret) (0.5.1)
Building wheels for collected packages: pyod, pyLDAvis, alembic, prometheus-flask-exporter, databricks-cli, htmlmin, combo, suod
  Building wheel for pyod (setup.py) ... done
    Created wheel for pyod: filename=pyod-0.8.4-cp36-none-any.whl size=11208
  3 sha256=a471de2dd4382c017b192337bc0628eb246103d9b2d97611558a752d26222330
  Stored in directory: /root/.cache/pip/wheels/ad/31/0a/c2d4ba2d066145c55f0cb2846e59b18d874cb59c5d9adc81cf
  Building wheel for pyLDAvis (setup.py) ... done
    Created wheel for pyLDAvis: filename=pyLDAvis-2.1.2-py2.py3-none-any.whl size=97712 sha256=d2ecf4b570280807565905d7c00652d7cc6567796ba05903774ebbce2bdd0e6
  Stored in directory: /root/.cache/pip/wheels/98/71/24/513a99e58bb6b8465bae4d2d5e9dba8f0bef8179e3051ac414
  Building wheel for alembic (setup.py) ... done
    Created wheel for alembic: filename=alembic-1.4.1-py2.py3-none-any.whl size=158155 sha256=daeebed61fc860bb4c69e57baece187908e7788a09f7f4fb858d9c61e6be50f5
  Stored in directory: /root/.cache/pip/wheels/84/07/f7/12f7370ca47a6603c2e0edcc23dec26ea0ac22dc4c4a0f3
  Building wheel for prometheus-flask-exporter (setup.py) ... done
    Created wheel for prometheus-flask-exporter: filename=prometheus_flask_exporter-0.18.1-cp36-none-any.whl size=17157 sha256=46633e0237a1d1ad9ffa972dbce131c5afe37cdfb7cbbd51f9b7ea91ceb969aa
  Stored in directory: /root/.cache/pip/wheels/b4/1f/b8/66bd9bc3a9d6c6987ff6c4dfeb6f1fe97b5a0e5ed5849c0437
  Building wheel for databricks-cli (setup.py) ... done
    Created wheel for databricks-cli: filename=databricks_cli-0.14.1-cp36-none-any.whl size=100579 sha256=09cb8c6e810a1b99da3714465565fe3a26f395dfad33e291c3a81141519b01a8
  Stored in directory: /root/.cache/pip/wheels/82/91/ac/5d417ee5ccb76c8cc0a096cf4cfb9ed9d49d889d1d1ca0fc39
  Building wheel for htmlmin (setup.py) ... done
    Created wheel for htmlmin: filename=htmlmin-0.1.12-cp36-none-any.whl size=27085 sha256=bf465298c5b13883eab147895324943e629c4e7237f79dd0b7b7d4836e1c7826
  Stored in directory: /root/.cache/pip/wheels/43/07/ac/7c5a9d708d65247ac1f94066cf1db075540b85716c30255459
  Building wheel for combo (setup.py) ... done
    Created wheel for combo: filename=combo-0.1.1-cp36-none-any.whl size=42113 sha256=0d6b8216de3685a39c236195f53ca74f78df4bc54ef73b9b8f338c6b9e1e3992
  Stored in directory: /root/.cache/pip/wheels/55/ec/e5/a2331372c676c467e70c6646e646edf6997d5c4905b8c0f5e6
  Building wheel for suod (setup.py) ... done
    Created wheel for suod: filename=suod-0.0.4-cp36-none-any.whl size=2167158 sha256=4056339cc25b904c1aaa9dc45a7e0db7858acc539af9391511398fd871a10ab8
  Stored in directory: /root/.cache/pip/wheels/57/55/e5/a4fca65bba231f6d0115059b589148774b41faea25b3f2aa27
Successfully built pyod pyLDAvis alembic prometheus-flask-exporter databricks-cli htmlmin combo suod
ERROR: pandas-profiling 2.9.0 has requirement tqdm>=4.43.0, but you'll have tqdm 4.41.1 which is incompatible.
Installing collected packages: xgboost, isodate, msrest, cryptography, azure-core, azure-storage-blob, smmap, gitdb, gitpython, Mako, python-editor, alembic, prometheus-flask-exporter, databricks-cli, querystring-parser, gunicorn, websocket-client, docker, mlflow, threadpoolctl, scikit-learn, kmodes, catboost, lightgbm, scikit-plot, imbalanced-learn, yellowbrick, tangled-up-in-unicode, htmlmin, confuse, phik, imagehash, visions, pandas-profiling, combo, suod, pyod, funcy, pyLDAvis, pycaret
  Found existing installation: xgboost 0.90
    Uninstalling xgboost-0.90:
```

```
Successfully uninstalled xgboost-0.90
Found existing installation: scikit-learn 0.22.2.post1
  Uninstalling scikit-learn-0.22.2.post1:
    Successfully uninstalled scikit-learn-0.22.2.post1
Found existing installation: lightgbm 2.2.3
  Uninstalling lightgbm-2.2.3:
    Successfully uninstalled lightgbm-2.2.3
Found existing installation: imbalanced-learn 0.4.3
  Uninstalling imbalanced-learn-0.4.3:
    Successfully uninstalled imbalanced-learn-0.4.3
Found existing installation: yellowbrick 0.9.1
  Uninstalling yellowbrick-0.9.1:
    Successfully uninstalled yellowbrick-0.9.1
Found existing installation: pandas-profiling 1.4.1
  Uninstalling pandas-profiling-1.4.1:
    Successfully uninstalled pandas-profiling-1.4.1
Successfully installed Mako-1.1.3 alembic-1.4.1 azure-core-1.9.0 azure-sto
rage-blob-12.6.0 catboost-0.24.3 combo-0.1.1 confuse-1.4.0 cryptography-3.
2.1 databricks-cli-0.14.1 docker-4.4.0 fancy-1.15 gitdb-4.0.5 gitpython-3.
1.11 gunicorn-20.0.4 htmlmin-0.1.12 imagehash-4.2.0 imbalanced-learn-0.7.0
isodate-0.6.0 kmodes-0.10.2 lightgbm-3.1.0 mlflow-1.12.1 msrest-0.6.19 pan
das-profiling-2.9.0 phik-0.10.0 prometheus-flask-exporter-0.18.1 pyLDAvis-
2.1.2 pycaret-2.2.2 pyod-0.8.4 python-editor-1.0.4 querystring-parser-1.2.
4 scikit-learn-0.23.2 scikit-plot-0.3.7 smmap-3.0.4 suod-0.0.4 tangled-up-
in-unicode-0.0.6 threadpoolctl-2.1.0 visions-0.5.0 websocket-client-0.57.0
xgboost-1.2.1 yellowbrick-1.2
```

In [2]:

```
from pycaret.utils import enable_colab
enable_colab()
```

Colab mode enabled.

2.0 資料集說明

此課程，將使用來自 [kaggle \(https://www.kaggle.com/shasun/tool-wear-detection-in-cnc-mill\)](https://www.kaggle.com/shasun/tool-wear-detection-in-cnc-mill) 的名為“CNC機台銑刀磨損(CNC Mill Tool Wear)資料集”，此資料來自密西根大學系統級製造和自動化研究試驗台的CNC銑床上，在 2" x 2" x 1.5" 蟻塊上進行了一系列機加工實驗，成品如下：



加工所收集的資料是的時間序列，從18次實驗中收集的，取樣率為100ms，分別記錄在experiment_01.csv到experiment_18.csv。共有48個特徵包含X、Y、Z軸和主軸的座標、轉速、加速度、電流、電壓、功率、回授電流和總線壓降，以及加工程式碼編號、加工工件編號、機台進給率與機台工序名稱等，標籤為是否換刀。在18次加工資料中，10筆為已破損需換刀(worn)，以及8筆為未破損無須換刀(unworn)。總計共有25286筆資料樣本與48個特徵。

每列的簡短描述如下：

- **ActualPosition:** X、Y、Z與S軸的座標。
- **ActualVelocity:** X、Y、Z與S軸的轉速。
- **ActualAcceleration:** X、Y、Z與S軸的加速度。
- **CommandPosition:** X、Y、Z與S軸的指令座標。
- **CommandVelocity:** X、Y、Z與S軸的指令速度。
- **CommandAcceleration:** X、Y、Z與S軸的指令加速度。
- **CurrentFeedback:** X、Y、Z與S軸的回授電流。
- **DCBusVoltage:** X、Y、Z與S軸的直流總線電壓。
- **OutputCurrent:** X、Y、Z與S軸的輸出電流。
- **OutputVoltage:** X、Y、Z與S軸的輸出電壓。
- **OutputPower:** X、Y、Z與S軸的輸出功率。
- **OutputPower:** X、Y、Z與S軸的輸出功率。
- **OutputPower:** X、Y、Z與S軸的輸出功率。
- **OutputPower:** X、Y、Z與S軸的輸出功率。
- **CURRENT_PROGRAM_NUMBER:** 加程式碼編號
- **sequence_number:** 加工工件編號
- **CURRENT_FEEDRATE:** 機台進給率
- **Machining_Process:** 機台正在執行的工序(分別為"Layer 1 Up", "Layer 1 Down", "Layer 2 Up", "Layer 2 Down", "Layer 3 Up", and "Layer 3 Down")
- **tool_condition:** 刀具條件(1 = 破損(worn), 0 = 無破損(unworn))

資料集來源：

[kaggle CNC Mill Tool Wear \(<https://www.kaggle.com/shasun/tool-wear-detection-in-cnc-mill>\)](https://www.kaggle.com/shasun/tool-wear-detection-in-cnc-mill)

3.0 獲取資料

可以從[此處 \(https://www.kaggle.com/shasun/tool-wear-detection-in-cnc-mill/download\)](https://www.kaggle.com/shasun/tool-wear-detection-in-cnc-mill/download)找到的原始下載資料，然後使用pandas進行載入（了解操作方法）。使用experiment_2,6,12,18.csv作為測試資料集，其餘為訓練資料集。

In [3]:

```
import pandas as pd
# training data set
frames = list()
url="https://raw.githubusercontent.com/y-s-liu/machine-learning-tutorial/master/datasets/CNC_Mill_Tool_Wear/train.csv"
results = pd.read_csv(url)
for i in [1, 3, 4, 5, 7, 8, 9, 10, 11, 13, 14, 15, 16, 17]:
    exp = '0' + str(i) if i < 10 else str(i)
    frame = pd.read_csv("https://raw.githubusercontent.com/y-s-liu/machine-learning-tutorial/master/datasets/CNC_Mill_Tool_Wear/experiment_{}.csv".format(exp))
    row = results[results['No'] == i]
    frame['target'] = 1 if row.iloc[0]['tool_condition'] == 'worn' else 0
    frames.append(frame)
dataset = pd.concat(frames, ignore_index = True)
dataset.head()

# testing data set
frames = list()
for i in [2, 6, 12, 18]:
    exp = '0' + str(i) if i < 10 else str(i)
    frame = pd.read_csv("https://raw.githubusercontent.com/y-s-liu/machine-learning-tutorial/master/datasets/CNC_Mill_Tool_Wear/experiment_{}.csv".format(exp))
    row = results[results['No'] == i]
    frame['target'] = 1 if row.iloc[0]['tool_condition'] == 'worn' else 0
    frames.append(frame)
data_unseen = pd.concat(frames, ignore_index = True)

print('Data for Modeling: ' + str(dataset.shape))
print('Unseen Data For Predictions: ' + str(data_unseen.shape))
```

Data for Modeling: (17793, 49)
 Unseen Data For Predictions: (7493, 49)

4.0 設定 PyCaret 環境

In [4]:

```
from pycaret.classification import *
```

In [5]:

```
exp_clf101 = setup(data = dataset, target = 'target', session_id=123)
```

| | Description | Value |
|----|--|------------------|
| 0 | session_id | 123 |
| 1 | Target | target |
| 2 | Target Type | Binary |
| 3 | Label Encoded | 0: 0, 1: 1 |
| 4 | Original Data | (17793, 49) |
| 5 | Missing Values | False |
| 6 | Numeric Features | 47 |
| 7 | Categorical Features | 1 |
| 8 | Ordinal Features | False |
| 9 | High Cardinality Features | False |
| 10 | High Cardinality Method | None |
| 11 | Transformed Train Set | (12455, 51) |
| 12 | Transformed Test Set | (5338, 51) |
| 13 | Shuffle Train-Test | True |
| 14 | Stratify Train-Test | False |
| 15 | Fold Generator | StratifiedKFold |
| 16 | Fold Number | 10 |
| 17 | CPU Jobs | -1 |
| 18 | Use GPU | False |
| 19 | Log Experiment | False |
| 20 | Experiment Name | clf-default-name |
| 21 | USI | 3306 |
| 22 | Imputation Type | simple |
| 23 | Iterative Imputation Iteration | None |
| 24 | Numeric Imputer | mean |
| 25 | Iterative Imputation Numeric Model | None |
| 26 | Categorical Imputer | constant |
| 27 | Iterative Imputation Categorical Model | None |
| 28 | Unknown Categoricals Handling | least_frequent |
| 29 | Normalize | False |
| 30 | Normalize Method | None |
| 31 | Transformation | False |
| 32 | Transformation Method | None |
| 33 | PCA | False |
| 34 | PCA Method | None |
| 35 | PCA Components | None |
| 36 | Ignore Low Variance | False |
| 37 | Combine Rare Levels | False |

| | Description | Value |
|----|------------------------------|-------|
| 38 | Rare Level Threshold | None |
| 39 | Numeric Binning | False |
| 40 | Remove Outliers | False |
| 41 | Outliers Threshold | None |
| 42 | Remove Multicollinearity | False |
| 43 | Multicollinearity Threshold | None |
| 44 | Clustering | False |
| 45 | Clustering Iteration | None |
| 46 | Polynomial Features | False |
| 47 | Polynomial Degree | None |
| 48 | Trigonometry Features | False |
| 49 | Polynomial Threshold | None |
| 50 | Group Features | False |
| 51 | Feature Selection | False |
| 52 | Features Selection Threshold | None |
| 53 | Feature Interaction | False |
| 54 | Feature Ratio | False |
| 55 | Interaction Threshold | None |
| 56 | Fix Imbalance | False |
| 57 | Fix Imbalance Method | SMOTE |

5.0 比較所有模型(Comparing All Models)

In [6]:

```
best_model = compare_models()
```

| | Model | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC | TT (Sec) |
|-----------------|---------------------------------|----------|--------|--------|--------|--------|--------|--------|-------------|
| lightgbm | Light Gradient Boosting Machine | 0.9944 | 0.9996 | 0.9947 | 0.9950 | 0.9949 | 0.9887 | 0.9887 | 0.529 |
| catboost | CatBoost Classifier | 0.9939 | 0.9998 | 0.9965 | 0.9924 | 0.9945 | 0.9877 | 0.9877 | 14.319 |
| xgboost | Extreme Gradient Boosting | 0.9937 | 0.9998 | 0.9956 | 0.9930 | 0.9943 | 0.9873 | 0.9874 | 2.857 |
| rf | Random Forest Classifier | 0.9876 | 0.9993 | 0.9939 | 0.9837 | 0.9887 | 0.9748 | 0.9749 | 2.294 |
| dt | Decision Tree Classifier | 0.9869 | 0.9867 | 0.9887 | 0.9875 | 0.9881 | 0.9736 | 0.9736 | 0.133 |
| et | Extra Trees Classifier | 0.9802 | 0.9978 | 0.9843 | 0.9798 | 0.9821 | 0.9601 | 0.9601 | 1.399 |
| gbc | Gradient Boosting Classifier | 0.9777 | 0.9983 | 0.9958 | 0.9648 | 0.9800 | 0.9548 | 0.9554 | 4.239 |
| ada | Ada Boost Classifier | 0.9663 | 0.9939 | 0.9813 | 0.9584 | 0.9696 | 0.9317 | 0.9321 | 0.986 |
| knn | K Neighbors Classifier | 0.7727 | 0.8567 | 0.7684 | 0.8081 | 0.7877 | 0.5435 | 0.5444 | 0.531 |
| lr | Logistic Regression | 0.6165 | 0.6715 | 0.6871 | 0.6406 | 0.6629 | 0.2195 | 0.2204 | 1.948 |
| lda | Linear Discriminant Analysis | 0.6137 | 0.6787 | 0.6565 | 0.6456 | 0.6510 | 0.2184 | 0.2185 | 0.134 |
| ridge | Ridge Classifier | 0.6130 | 0.0000 | 0.6573 | 0.6447 | 0.6509 | 0.2169 | 0.2170 | 0.042 |
| nb | Naive Bayes | 0.5929 | 0.6394 | 0.4064 | 0.7336 | 0.5228 | 0.2158 | 0.2450 | 0.040 |
| svm | SVM - Linear Kernel | 0.5446 | 0.0000 | 0.4864 | 0.6412 | 0.5183 | 0.0991 | 0.1137 | 0.390 |
| qda | Quadratic Discriminant Analysis | 0.5168 | 0.5181 | 0.6302 | 0.3871 | 0.4785 | 0.0094 | 0.0142 | 0.075 |

6.0 建立模型(Create a Model)

In [7]:

```
lightgbm = create_model('lightgbm')
```

| | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|-------------|-----------------|------------|---------------|--------------|-----------|--------------|------------|
| 0 | 0.9936 | 0.9996 | 0.9942 | 0.9942 | 0.9942 | 0.9870 | 0.9870 |
| 1 | 0.9944 | 0.9999 | 0.9898 | 1.0000 | 0.9949 | 0.9887 | 0.9887 |
| 2 | 0.9952 | 0.9999 | 0.9971 | 0.9942 | 0.9956 | 0.9903 | 0.9903 |
| 3 | 0.9960 | 0.9999 | 0.9956 | 0.9971 | 0.9963 | 0.9919 | 0.9919 |
| 4 | 0.9928 | 0.9997 | 0.9956 | 0.9913 | 0.9934 | 0.9854 | 0.9854 |
| 5 | 0.9920 | 0.9998 | 0.9971 | 0.9884 | 0.9927 | 0.9838 | 0.9838 |
| 6 | 0.9960 | 0.9999 | 0.9956 | 0.9971 | 0.9963 | 0.9919 | 0.9919 |
| 7 | 0.9976 | 0.9999 | 0.9971 | 0.9985 | 0.9978 | 0.9951 | 0.9951 |
| 8 | 0.9928 | 0.9982 | 0.9912 | 0.9956 | 0.9934 | 0.9854 | 0.9854 |
| 9 | 0.9936 | 0.9988 | 0.9942 | 0.9942 | 0.9942 | 0.9870 | 0.9870 |
| Mean | 0.9944 | 0.9996 | 0.9947 | 0.9950 | 0.9949 | 0.9887 | 0.9887 |
| SD | 0.0017 | 0.0006 | 0.0024 | 0.0033 | 0.0015 | 0.0034 | 0.0034 |

7.0 調整模型(Tune a Model)

In [8]:

```
tuned_lightgbm = tune_model(lightgbm)
```

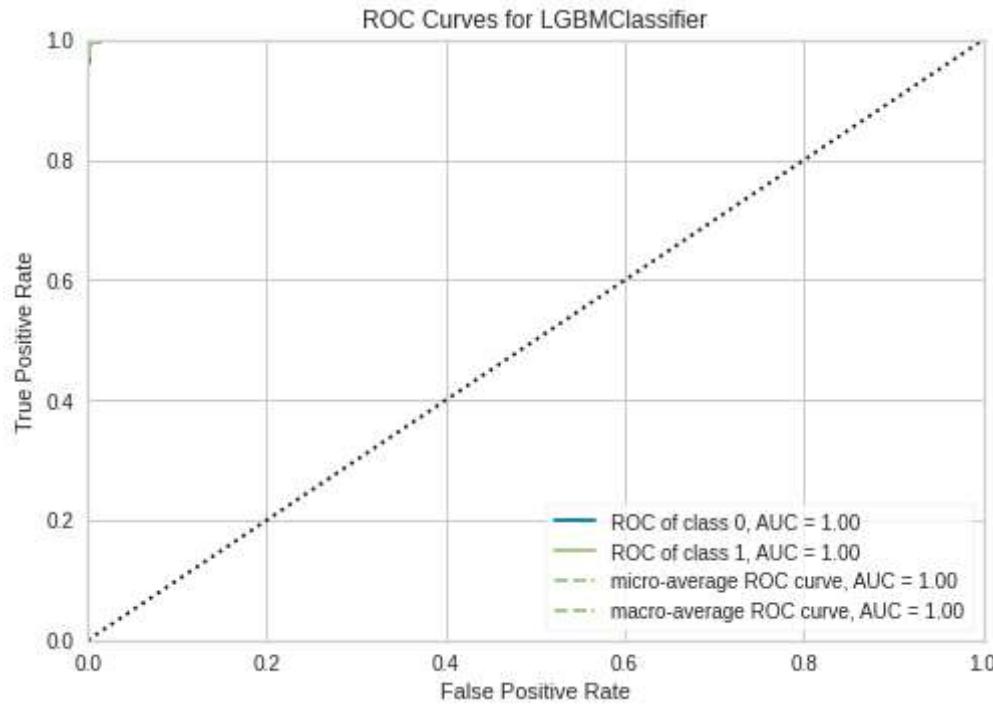
| | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|-------------|-----------------|------------|---------------|--------------|-----------|--------------|------------|
| 0 | 0.9920 | 0.9997 | 0.9942 | 0.9913 | 0.9927 | 0.9838 | 0.9838 |
| 1 | 0.9960 | 0.9999 | 0.9956 | 0.9971 | 0.9963 | 0.9919 | 0.9919 |
| 2 | 0.9928 | 0.9998 | 0.9971 | 0.9898 | 0.9934 | 0.9854 | 0.9854 |
| 3 | 0.9936 | 0.9999 | 0.9971 | 0.9913 | 0.9942 | 0.9870 | 0.9870 |
| 4 | 0.9920 | 0.9996 | 0.9971 | 0.9884 | 0.9927 | 0.9838 | 0.9838 |
| 5 | 0.9896 | 0.9997 | 0.9956 | 0.9855 | 0.9905 | 0.9789 | 0.9790 |
| 6 | 0.9928 | 0.9998 | 0.9927 | 0.9941 | 0.9934 | 0.9854 | 0.9854 |
| 7 | 0.9952 | 0.9999 | 0.9956 | 0.9956 | 0.9956 | 0.9903 | 0.9903 |
| 8 | 0.9936 | 0.9997 | 0.9927 | 0.9956 | 0.9941 | 0.9870 | 0.9870 |
| 9 | 0.9880 | 0.9994 | 0.9912 | 0.9869 | 0.9891 | 0.9757 | 0.9757 |
| Mean | 0.9925 | 0.9997 | 0.9949 | 0.9916 | 0.9932 | 0.9849 | 0.9849 |
| SD | 0.0023 | 0.0001 | 0.0020 | 0.0038 | 0.0021 | 0.0046 | 0.0046 |

8.0 各種圖形分析模型性能(Plot a Model)

8.1 AUC Plot

In [9]:

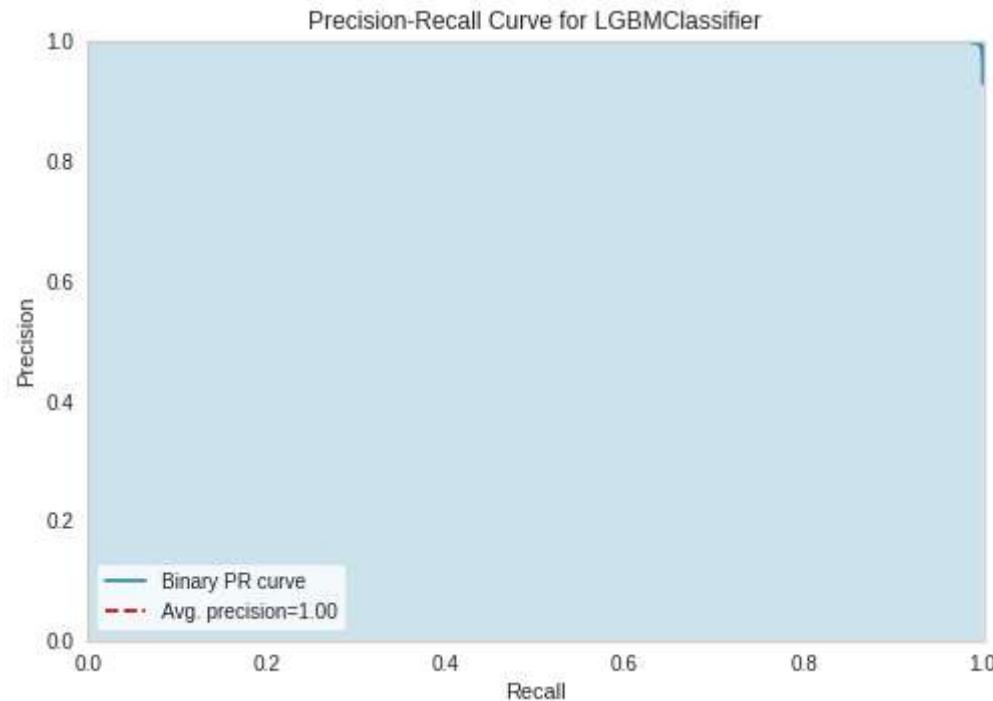
```
plot_model(tuned_lightgbm, plot = 'auc')
```



8.2 Precision-Recall Curve

In [10]:

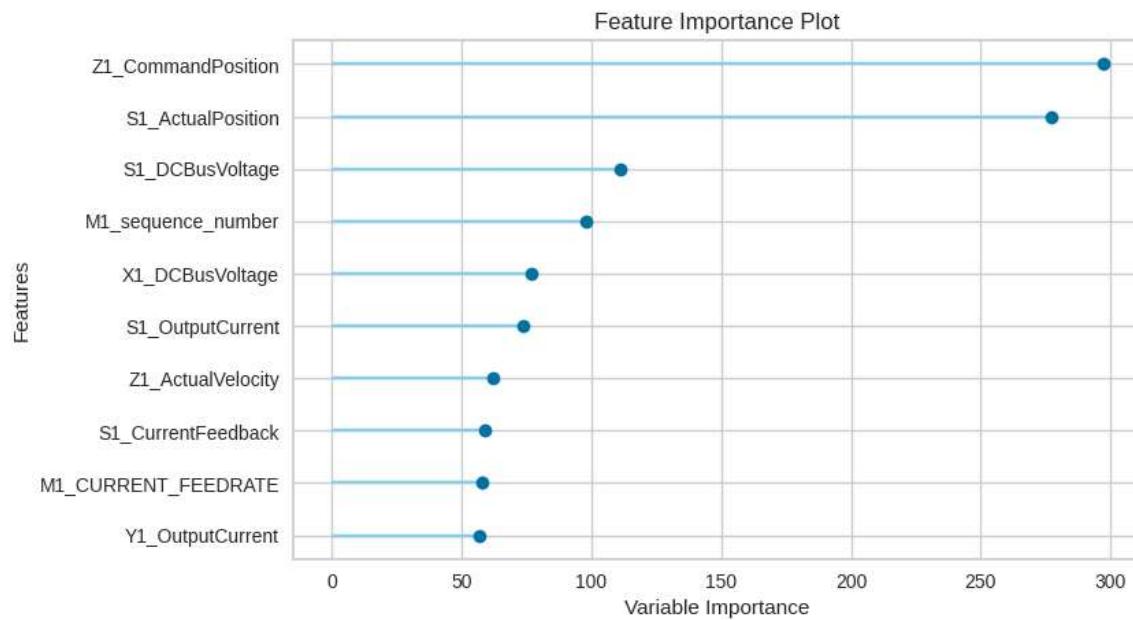
```
plot_model(tuned_lightgbm, plot = 'pr')
```



8.3 Feature Importance Plot

In [11]:

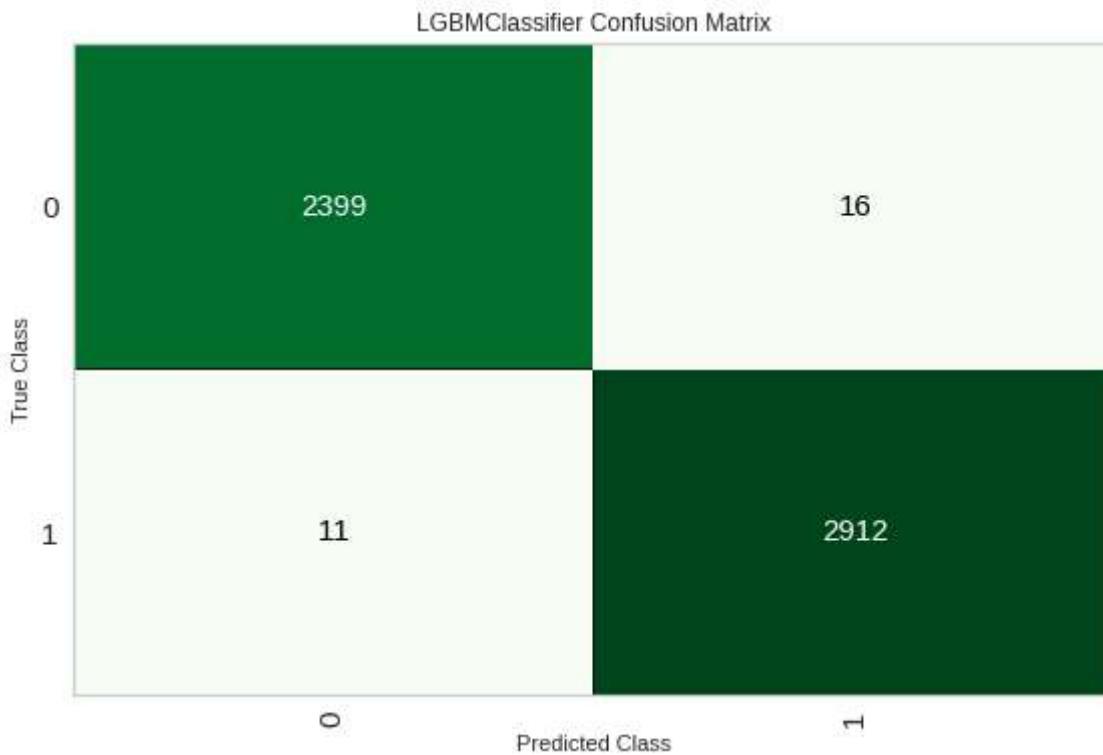
```
plot_model(tuned_lightgbm, plot='feature')
```



8.4 Confusion Matrix

In [12]:

```
plot_model(tuned_lightgbm, plot = 'confusion_matrix')
```



分析模型性能的另一種方法是使用 `valuate_model` 函式，該函式顯示給定模型的所有可用圖形的使用者界面。它在內部是使用 `plot_model` 函式。

9.0 預測測試資料樣本(Predict on test Sample)

In [13]:

```
predict_model(tuned_lightgbm);
```

| | Model | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|---|---------------------------------|----------|--------|--------|--------|--------|--------|--------|
| 0 | Light Gradient Boosting Machine | 0.9949 | 0.9999 | 0.9962 | 0.9945 | 0.9954 | 0.9898 | 0.9898 |

10.0 部署模型確定(Finalize Model for Deployment)

In [14]:

```
final_lightgbm = finalize_model(tuned_lightgbm)
```

In [15]:

```
predict_model(final_lightgbm)
```

| | Model | Accuracy | AUC | Recall | Prec. | F1 | Kappa | MCC |
|---|---------------------------------|----------|-----|--------|-------|-----|-------|-----|
| 0 | Light Gradient Boosting Machine | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |

Out[15]:

| | X1_ActualVelocity | X1_ActualAcceleration | X1_CommandPosition | X1_CommandAccelerati |
|------|-------------------|-----------------------|--------------------|----------------------|
| 0 | 0.000 | 0.000000 | 198.0 | 0.000C |
| 1 | 0.050 | 25.000000 | 151.0 | 0.000C |
| 2 | -0.150 | -68.699997 | 141.0 | 0.000C |
| 3 | 1.900 | 25.000000 | 162.0 | -2.730C |
| 4 | -0.025 | -6.250000 | 198.0 | 0.000C |
| ... | ... | ... | ... | ... |
| 5333 | -3.100 | -6.250000 | 153.0 | 0.000C |
| 5334 | 2.950 | -175.000000 | 159.0 | -99.900C |
| 5335 | 15.100 | 37.500000 | 149.0 | 0.000C |
| 5336 | -0.025 | -12.500000 | 151.0 | 0.000C |
| 5337 | 0.000 | 0.000000 | 198.0 | 0.000C |

5338 rows × 54 columns



11.0 預測未見過的資料集(Predict on unseen data)

In [16]:

```
unseen_predictions = predict_model(final_lightgbm, data=data_unseen)
unseen_predictions.head()
```

Out[16]:

| | X1_ActualPosition | X1_ActualVelocity | X1_ActualAcceleration | X1_CommandPosition | X1_Co |
|---|-------------------|-------------------|-----------------------|--------------------|-------|
| 0 | 198.0 | 0.0 | 0.0 | 198.0 | |
| 1 | 198.0 | 0.0 | 0.0 | 198.0 | |
| 2 | 198.0 | 0.0 | 0.0 | 198.0 | |
| 3 | 198.0 | 0.0 | 0.0 | 198.0 | |
| 4 | 198.0 | 0.0 | 0.0 | 198.0 | |

In [17]:

```
from pycaret.utils import check_metric
check_metric(unseen_predictions.target, unseen_predictions.Label, 'Accuracy')
```

Out[17]:

0.8685