Contents

This notebook investigates the visualization of Conformal Prediction values for an individual prediction.

We investigate how an individual prediction may be visualized in an intuitive manner, of most interest to a clinician seeing an individual patient in clinical practice.

To a clinician looking at a prediction of high/low breast cancer risk for an individual patient, the most informative attributes of the corresponding conformal prediction are credibility and confidence. In this case, credibility is what proportion of the time the prediction is expected to be true, and confidence is what proportion of the time the opposite of the prediction is not expected to be true. A key aspect of making this information useful in clinical practice is finding an intuitive means to present these measures of uncertainty with the individual-patient prediction. What defines intuitive is the ability of the visual representation to provide the clinician with a sense of how certain they are that the prediction of either high or low risk is correct without any explicit explanation of how different combinations of a prediction's credibility and confidence should be interpreted.

In [1]:
```
#imports/pwd
import os

# set pwd to root of repository
repo_root = 'C:/Users/Bob/CHPC/conformal_prediction/vigilant-computing-machine/'
os.chdir(repo_root)

# 'vigilant-computing-machine/source/util.py'
import source.util as util
import matplotlib.pyplot as plt
import numpy as np
import pandas as pd

from IPython.display import Image
```

---

read in experiment results

In [2]:
```
experiments = [util.read_experiment('./results/logistic_regression_12000_rrr_balanced_experiment.csv'),
               util.read_experiment('./results/logistic_regression_12000_rrr_imbalanced_experiment.csv'),
               util.read_experiment('./results/logistic_regression_12000_rrr_balanced_mondrian_experiment.csv'),
               util.read_experiment('./results/logistic_regression_12000_rrr_imbalanced_mondrian_experiment.csv'),
               util.read_experiment('./results/rf_12000_rrr_balanced_experiment.csv'),
               util.read_experiment('./results/rf_12000_rrr_imbalanced_experiment.csv'),
               util.read_experiment('./results/rf_12000_rrr_balanced_mondrian_experiment.csv'),
               util.read_experiment('./results/rf_12000_rrr_imbalanced_mondrian_experiment.csv'),
               util.read_experiment('./results/knn_12000_rrr_balanced_experiment.csv'),
               util.read_experiment('./results/knn_12000_rrr_imbalanced_experiment.csv'),
               util.read_experiment('./results/knn_12000_rrr_balanced_mondrian_experiment.csv'),
               util.read_experiment('./results/knn_12000_rrr_imbalanced_mondrian_experiment.csv'),
               util.read_experiment('./results/ada_12000_rrr_balanced_experiment.csv'),
               util.read_experiment('./results/ada_12000_rrr_imbalanced_experiment.csv'),
               util.read_experiment('./results/ada_12000_rrr_balanced_mondrian_experiment.csv'),
               util.read_experiment('./results/ada_12000_rrr_imbalanced_mondrian_experiment.csv'),
               util.read_experiment('./results/knn_fraction_12000_rrr_balanced_experiment.csv'),
               util.read_experiment('./results/knn_fraction_12000_rrr_imbalanced_experiment.csv'),
               util.read_experiment('./results/knn_fraction_12000_rrr_balanced_mondrian_experiment.csv'),
               util.read_experiment('./results/knn_fraction_12000_rrr_imbalanced_mondrian_experiment.csv')]

idx = util.get_low_confidence_predictions(experiments[1].df[0]).head(1).index.values[0]

min_conf_among_exps_max_conf_in_low_conf_region = \
    np.percentile(util.get_experiments_max_low_confidence(experiments), 75)

min_cred_among_exps_median_cred_in_low_cred_region = \
    np.percentile(util.get_experiments_max_low_credibility(experiments), 75)
```

---

define plot function

In [3]:
```
import plotly.graph_objects as go
```

```
def plot_prediction_uncertainty(s):
    pred = s
    pred_classes = s.loc['classes']
    min_cred = min_cred_among_exps_median_cred_in_low_cred_region*100
    min_conf = min_conf_among_exps_max_conf_in_low_conf_region*100
    conf = pred.confidence*100
    cred = pred.credibility*100
    insufficient_cred = cred < min_cred
    insufficient_conf = conf < min_conf
    second_most_cred = (1 - pred.credibility) * 100
    empty_pred = len(pred_classes) == 0
    cred_threshold_clr = 'red' if insufficient_cred else 'lime'
    conf_color = 'red' if insufficient_conf else 'green'
    num_color = 'red' if insufficient_conf or \
                         insufficient_cred or \
                         empty_pred else 'black'

    fig=go.Figure(go.Indicator(
        domain={'x': [0, 1], 'y': [0, 1]},
        value=conf,
        number_font_color=num_color,
        title_font_color= 'red' if empty_pred else 'black',
        mode='gauge+number+delta',
        title={'text':f'Prediction: {pred_classes}'},
        delta={'reference':second_most_cred},
        gauge={'axis': {'range': [None,100]},
               'steps': [
                   {'range': [min_conf,100], 'color': 'lightgray'},
                   {'range': [0,min_cred], 'color': 'tomato'}],
               'threshold': {'line': {'color': cred_threshold_clr, 'width': 4}, 'thickness': 0.75, 'value': cred}}))
    fig.show()
```

---

visualize individual prediction from first CP

In [4]:

```
pred = experiments[0].df[0].loc[idx]
plot_prediction_uncertainty(pred)
pd.DataFrame(pred).T

#image per plotly vs PDF
Image(filename='source/Notebooks/conformal_pred_sufficient.PNG')
```

Out[4]:

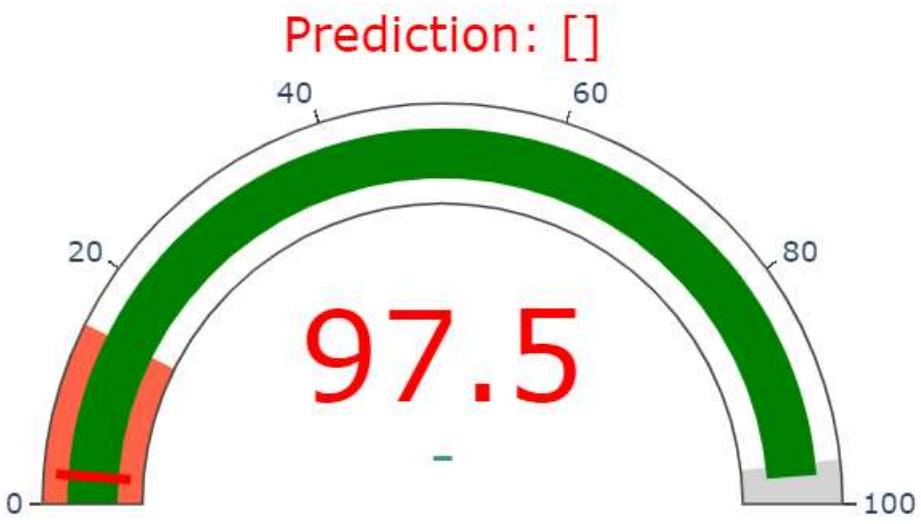
	classes	confidence	credibility	eps	p	verdict
480	[1]	0.9975	0.241813	0.1	[(0.0024997916840263 31, '0'), (0.2418131822348...	True

---

visualize individual prediction from second CP

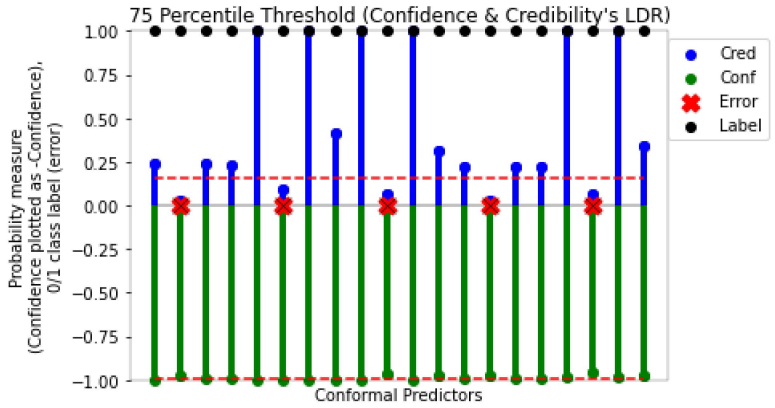
In [5]:
```
pred = experiments[1].df[0].loc[idx]
plot_prediction_uncertainty(pred)
pd.DataFrame(pred).T

#image per plotly vs PDF
Image(filename='source/Notebooks/conformal_pred_insufficient.PNG')
```

Out[5]:



	classes	confidence	credibility	eps	p	verdict
480	[]	0.975458	0.024542	0.1	[(0.02454173610059082, '0'), (0.02454173610059...	False

In [6]:
```
util.plot_prediction(preds_list_s=[exp.df[0].iloc[idx] for exp in experiments],
                     min_conf=min_conf_among_exps_max_conf_in_low_conf_region,
                     min_cred=min_cred_among_exps_median_cred_in_low_cred_region,
                     title='75 Percentile Threshold (Confidence & Credibility\'s LDR)')
```



Discussion:

Our hope is that **intuitive representation** of **Conformal Prediction** values will **inform clinicians** when **assessing uncertainty** surrounding an **individual prediction** without being too cumbersome to actually be used **in practice**.