distributions

May 13, 2024

1 Imports

[1]:
```
import numpy as np
import matplotlib.pyplot as plt
import plotly.graph_objects as go
import pandas as pd
import seaborn as sns

sns.set_theme()
```

2 Load Data and Preprocessing

[2]:
```
from loadAndPreprocess import load_and_preprocess

'''
well_info: Well, X, Y, Total Resources
sensor_data: Depth, Porosity, Hydrate Saturation, Estimated Resources
'''
well_info, sensor_data_list = load_and_preprocess()
```

3 Get the Statistical Distribution

[3]:
```
def drop_outliers(data: np.ndarray, threshold=3):
    z = np.abs((data - data.mean()) / data.std())
    return data[z < threshold]
```

[4]:
```
def fit_norm_and_plot(data: np.ndarray, name: str):
    from scipy.stats import norm
    mu, std = norm.fit(data)

    # Plot the distribution of the hydrate saturation
    plt.figure(figsize=(10, 6))
    plt.hist(data, bins=40, density=True, alpha=0.7)

    xmin, xmax = plt.xlim()
    x = np.linspace(xmin, xmax, 100)
```

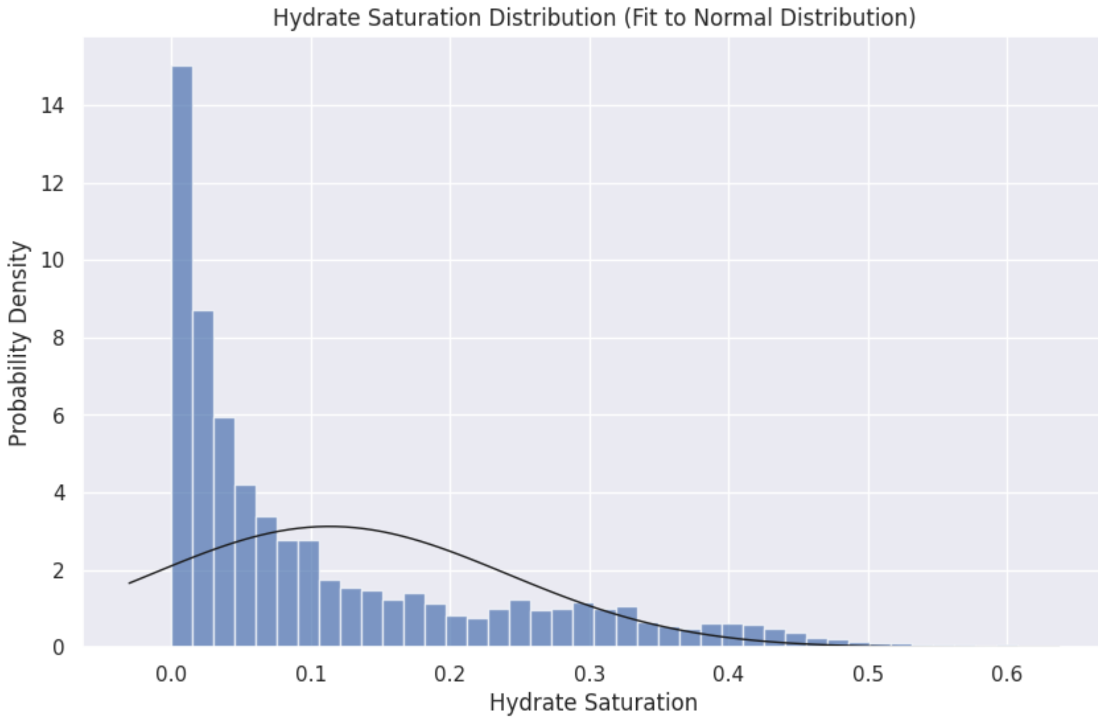
```
    p = norm.pdf(x, mu, std)
    plt.plot(x, p, 'k', linewidth=1)

    plt.title(f'{name} Distribution (Fit to Normal Distribution)')
    plt.xlabel(name)
    plt.ylabel('Probability Density')
    plt.grid(True)
    plt.show()

    return mu, std
```

[5]:
```
def fit_gmm_and_plot(data: np.ndarray, name: str, n_components: int = 3) ->␣
↪object:
    from sklearn.mixture import GaussianMixture
    gmm = GaussianMixture(n_components=n_components, random_state=0)
    gmm.fit(data.reshape(-1, 1))

    # Plot the distribution
    plt.figure(figsize=(10, 6))
    plt.hist(data, bins=40, density=True, alpha=0.7, label='Data histogram')

    xmin, xmax = plt.xlim()
    x = np.linspace(xmin, xmax, 1000).reshape(-1, 1)
    logprob = gmm.score_samples(x)
    responsibilities = np.exp(logprob)

    plt.plot(x, responsibilities, 'k', linewidth=1, label=f'GMM fit␣
↪({n_components} compo)')

    plt.title(f'{name} Distribution (Fit to Gaussian Mixture Model)')
    plt.xlabel(name)
    plt.ylabel('Probability Density')
    plt.legend()
    plt.grid(True)
    plt.show()

    return gmm
```

3.0.1 Distribution of Hydrate Saturation

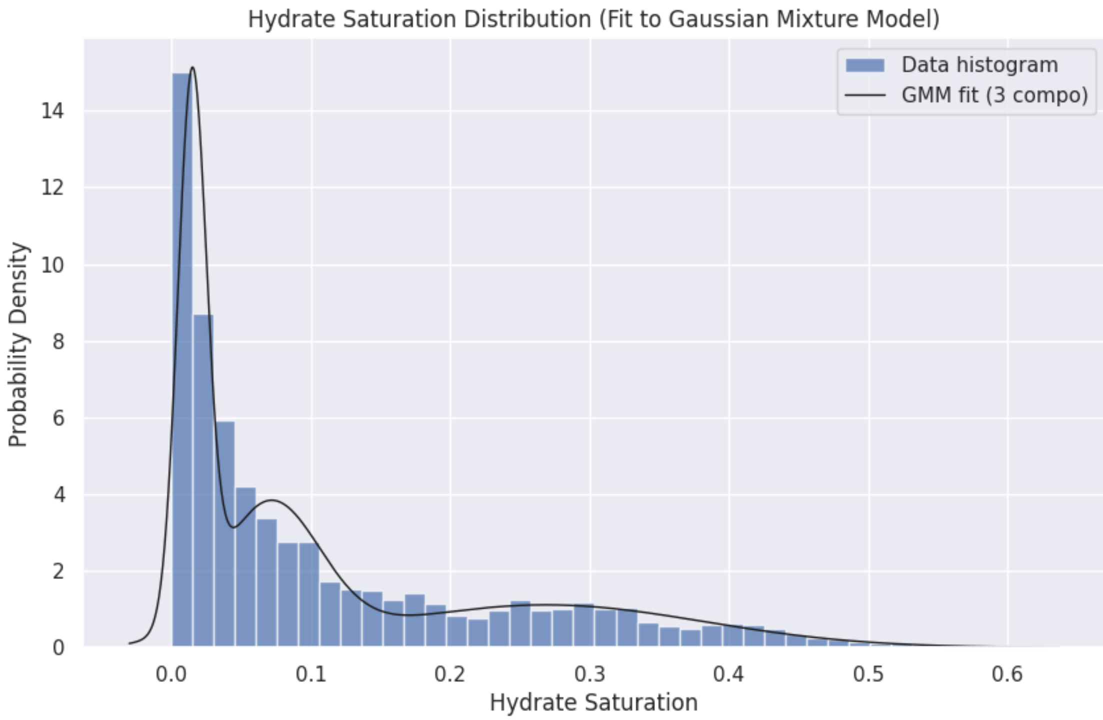
[6]:
```
# Get the distibution of the hydrate saturation
hydrate_saturation = []
for sensor_data in sensor_data_list:
    hydrate_saturation.extend(sensor_data['Hydrate Saturation'].dropna())

hydrate_saturation = np.array(hydrate_saturation)
```

```
fit_norm_and_plot(drop_outliers(hydrate_saturation[hydrate_saturation != 0]),␣
↪'Hydrate Saturation')
```



[6]: (0.11351333316926242, 0.12775385825103733)

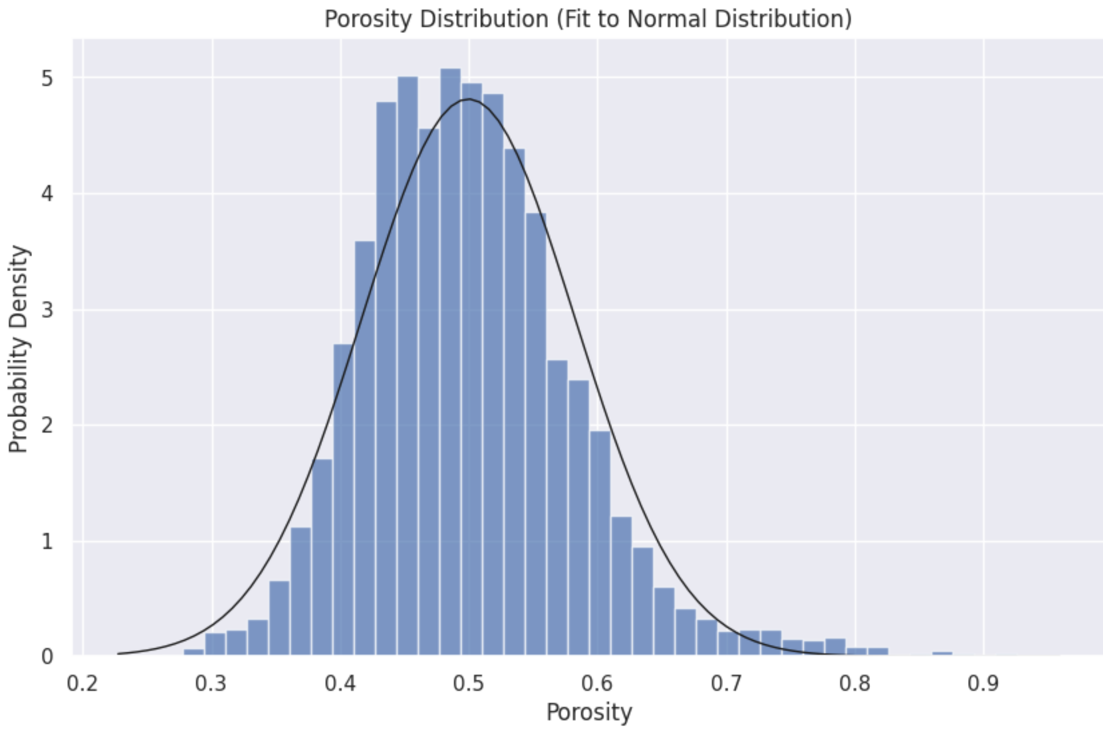
[7]:
```
fit_gmm_and_plot(drop_outliers(hydrate_saturation[hydrate_saturation != 0]),␣
↪'Hydrate Saturation', 3)
```



[7]: GaussianMixture(n_components=3, random_state=0)

3.0.2 Distribution of Porosity

[8]:
```
# Get the distibution of the porosity
porosity = []
for sensor_data in sensor_data_list:
    porosity.extend(sensor_data['Porosity'].dropna())

porosity = np.array(porosity)

fit_norm_and_plot(porosity, "Porosity")
```

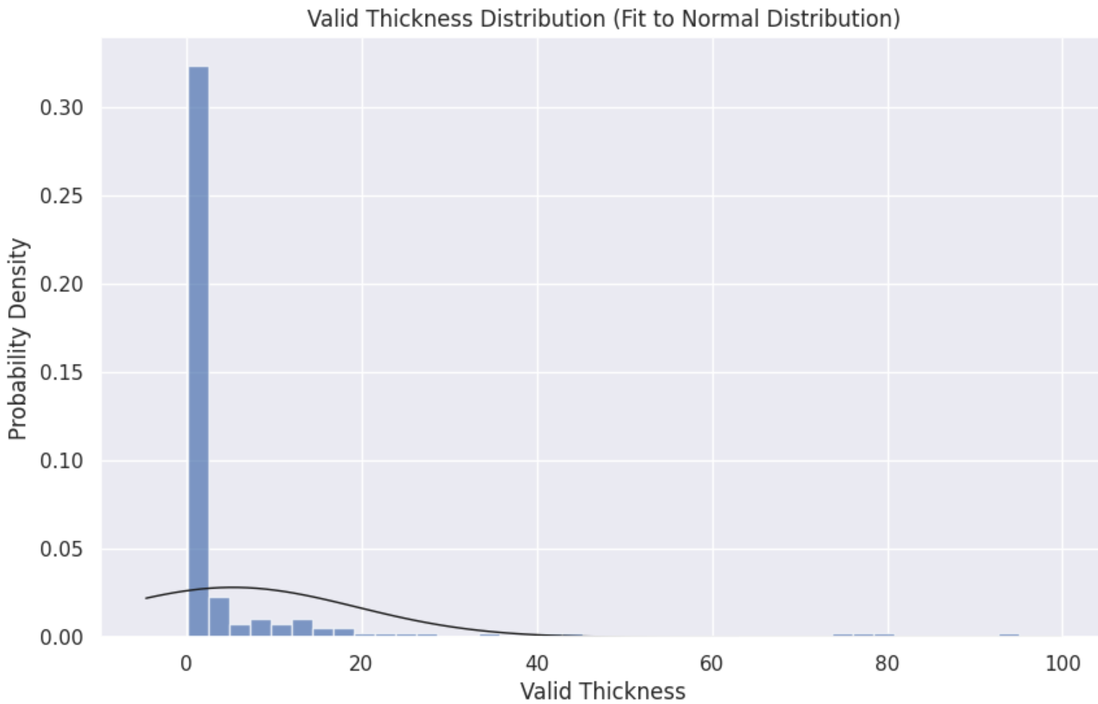


[8]: (0.49971813555638256, 0.0829126678872652)

3.0.3 Distribution of Valid Thickness

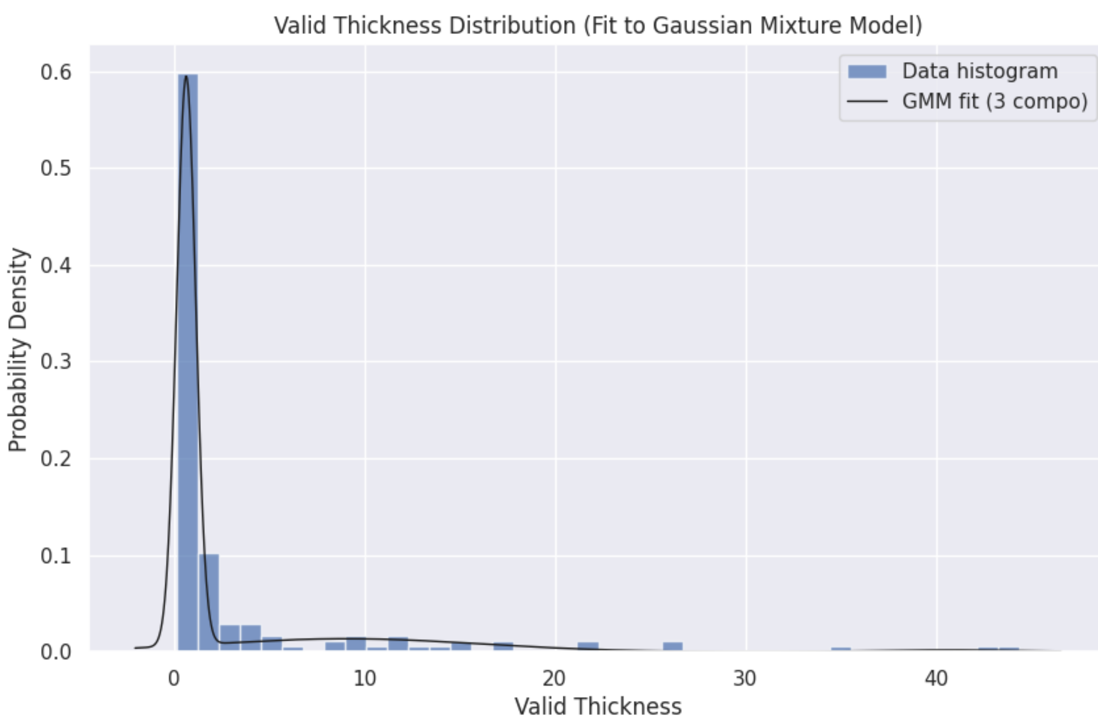
Valid thickness is the thickness of the an continual layer contains resources

[9]:
```python
# Calculate the valid thickness in each well.
valid_thickness = []
for sensor_data in sensor_data_list:
    sensor_data.dropna(inplace=True)
    flag = False
    for i in range(len(sensor_data)):
        if sensor_data.iloc[i]['Estimated Resources'] != 0 and flag == False:
            current_start = sensor_data.iloc[i]['Depth']
            flag = True
        if sensor_data.iloc[i]['Estimated Resources'] == 0 and flag == True:
            current_end = sensor_data.iloc[i]['Depth']
            valid_thickness.append(current_end - current_start)
            flag = False

valid_thickness = np.array(valid_thickness)
fit_norm_and_plot(valid_thickness, "Valid Thickness")
```



[9]: (5.313300613496928, 14.130376163965092)

[10]:
```
fit_gmm_and_plot(drop_outliers(valid_thickness, 3), "Valid Thickness")
```



[10]: GaussianMixture(n_components=3, random_state=0)

[11]:
```
# Calculate the valid thickness in each well.
v_thick_list = []
for sensor_data in sensor_data_list:
    cur_v_thick = 0
    sensor_data.dropna(inplace=True)
    flag = False
    for i in range(len(sensor_data)):
        if sensor_data.iloc[i]['Estimated Resources'] != 0 and flag == False:
            current_start = sensor_data.iloc[i]['Depth']
            flag = True
        if sensor_data.iloc[i]['Estimated Resources'] == 0 and flag == True:
            current_end = sensor_data.iloc[i]['Depth']
            cur_v_thick += (current_end - current_start)
            flag = False

    v_thick_list.append(cur_v_thick)

well_info["Valid Thickness"] = v_thick_list
```

[12]:
```
# Plot the Contour of the valid thickness
fig = go.Figure(data=[go.Contour(z=well_info["Valid Thickness"],␣
 ↪x=well_info['X'], y=well_info['Y'], colorscale='Viridis')])
fig.update_layout(
    height=600,
    width=700,
    title_text='Contour of Valid Thickness'
)

fig.show()
```

[13]:
```
# Plot the Contour of the Total Resources
fig = go.Figure(data=[go.Contour(z=well_info['Total Resources'],␣
 ↪x=well_info['X'], y=well_info['Y'], colorscale='Viridis')])
fig.update_layout(
    height=600,
    width=700,
    title_text='Total Resources'
)

fig.show()
```