Search for Beyond Standard Model Higgs boson using Machine Learning techniques

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Objective

H \rightarrow b\bar{b}

- Developing machine learning model to classify signal and background
- to be continue..
Data → Histogram → Select features → ... → Train/Test model → Standardization
## Simulated signal & background data from CMS detector

<table>
<thead>
<tr>
<th>signal</th>
<th>mbb</th>
<th>weight</th>
<th>njets</th>
<th>mbjets</th>
<th>pttbb</th>
<th>etabb</th>
<th>phi bb</th>
<th>ebb</th>
<th>dKbb</th>
<th>deta23</th>
<th>dphi23</th>
<th>m4j</th>
<th>ptj4</th>
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<th>sj4</th>
<th>btagj4</th>
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</table>

...
Select features

Selected features

['signal', 'm_bb', 'n_jets', 'e_ee', 'dR_bb', 'dR_ee', 'dPhi_bb', 'dPhi_ee', 'pt_j1', 'e_j1', 'pt_j2', 'eta_j2', 'btag_j2', 'qq_likelihood_j2', 'btag_j3', 'qq_likelihood_j3', 'dR_l3', 'dPhi_l3', 'btag_j4']
Standardization

\[ Z = \frac{X - \mu}{\sigma} \]

```python
from sklearn.preprocessing import StandardScaler
x_train_stand = StandardScaler().fit_transform(x_train)
x_test_stand = StandardScaler().fit_transform(x_test)
```
ML Model

Activation Function

**ReLU**
\[
\max(0, x)
\]

**Sigmoid**
\[
\sigma(x) = \frac{1}{1 + e^{-x}}
\]

Loss Function

**Binary Cross Entropy**
\[
J(\mathbf{w}) = \frac{1}{N} \sum_{n=1}^{N} H(p_n, q_n) = - \frac{1}{N} \sum_{n=1}^{N} \left[ y_n \log \hat{y}_n + (1 - y_n) \log (1 - \hat{y}_n) \right]
\]

Optimizer

**Adam** (Adaptive Moment Estimation)
<table>
<thead>
<tr>
<th>Epoch</th>
<th>1/10</th>
<th>11716/11716</th>
<th>36s 3ms/step</th>
<th>loss: 0.2037</th>
<th>accuracy: 0.9201</th>
<th>val_loss: 0.1916</th>
<th>val_accuracy: 0.9252</th>
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<tbody>
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<td>11716/11716</td>
<td>34s 3ms/step</td>
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</tbody>
</table>
END