gplearn (/github/trevorstephens/gplearn/tree/master) / doc (/github/trevorstephens/gplearn/tree/master/doc)

Example 1: Symbolic Regressor

In [1]:

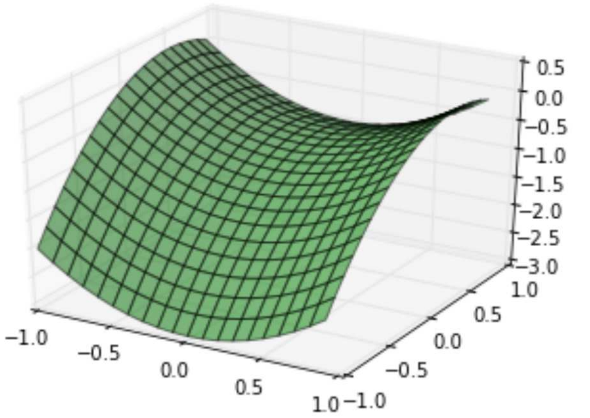
```
%pylab inline
from gplearn.genetic import SymbolicRegressor
from sklearn.ensemble import RandomForestRegressor
from sklearn.tree import DecisionTreeRegressor
from sklearn.utils.random import check_random_state
from mpl_toolkits.mplot3d import Axes3D
import matplotlib.pyplot as plt
import numpy as np
from IPython.display import Image
import pydotplus
```

```
Populating the interactive namespace from numpy and matplotlib
```

In [2]:

```
# Ground truth
x0 = np.arange(-1, 1, 1/10.)
x1 = np.arange(-1, 1, 1/10.)
x0, x1 = np.meshgrid(x0, x1)
y_truth = x0**2 - x1**2 + x1 - 1

ax = plt.figure().gca(projection='3d')
ax.set_xlim(-1, 1)
ax.set_ylim(-1, 1)
surf = ax.plot_surface(x0, x1, y_truth, rstride=1, cstride=1, color='gree
plt.show()
```

```
/home/trev/.virtualenvs/ve/lib/python2.7/site-packages/matplotlib/colle
  if self._edgecolors == str('face'):
```



In [3]:

```
rng = check_random_state(0)

# Training samples
X_train = rng.uniform(-1, 1, 100).reshape(50, 2)
y_train = X_train[:, 0]**2 - X_train[:, 1]**2 + X_train[:, 1] - 1

# Testing samples
X_test = rng.uniform(-1, 1, 100).reshape(50, 2)
y_test = X_test[:, 0]**2 - X_test[:, 1]**2 + X_test[:, 1] - 1
```

In [4]:

```
est_gp = SymbolicRegressor(population_size=5000,
                           generations=20, stopping_criteria=0.01,
                           p_crossover=0.7, p_subtree_mutation=0.1,
                           p_hoist_mutation=0.05, p_point_mutation=0.1,
                           max_samples=0.9, verbose=1,
                           parsimony_coefficient=0.01, random_state=0)
est_gp.fit(X_train, y_train)
```

```
    |    Population Average   |             Best Individual
---- ------------------------- ----------------------------------------
 Gen   Length          Fitness   Length          Fitness      OOB Fitnes
   0    38.13     386.19117972        7    0.33158080873    0.47028615225
   1     9.91    1.66832489614        5   0.335361761359    0.4883471495
   2     7.76      1.888657267        7   0.260765934398    0.5655175998
   3     5.37    1.00018638338       17   0.223753461954    0.27492043370
   4     4.69   0.878161643513       17     0.1450953226    0.1583595542
   5      6.1    0.91987274474       11  0.0436125629701  0.04361256297
   6     7.18    1.09868887802       11  0.0436125629701  0.04361256297
   7     7.65    1.96650325011       11  0.0436125629701  0.04361256297
   8     8.02    1.02643443398       11  0.0436125629701  0.04361256297
   9     9.07    1.22732144371       11 0.000781474035346 0.000781474035
```

Out[4]:

```
SymbolicRegressor(const_range=(-1.0, 1.0),
         function_set=('add', 'sub', 'mul', 'div'), generations=20,
         init_depth=(2, 6), init_method='half and half', max_samples=0.9
         metric='mean absolute error', n_jobs=1, p_crossover=0.7,
         p_hoist_mutation=0.05, p_point_mutation=0.1, p_point_replace=0
         p_subtree_mutation=0.1, parsimony_coefficient=0.01,
         population_size=5000, random_state=0, stopping_criteria=0.01,
         tournament_size=20, verbose=1)
```

In [5]:

```
print est_gp._program
```

```
sub(add(-0.999, X1), mul(sub(X1, X0), add(X0, X1)))
```

In [6]:

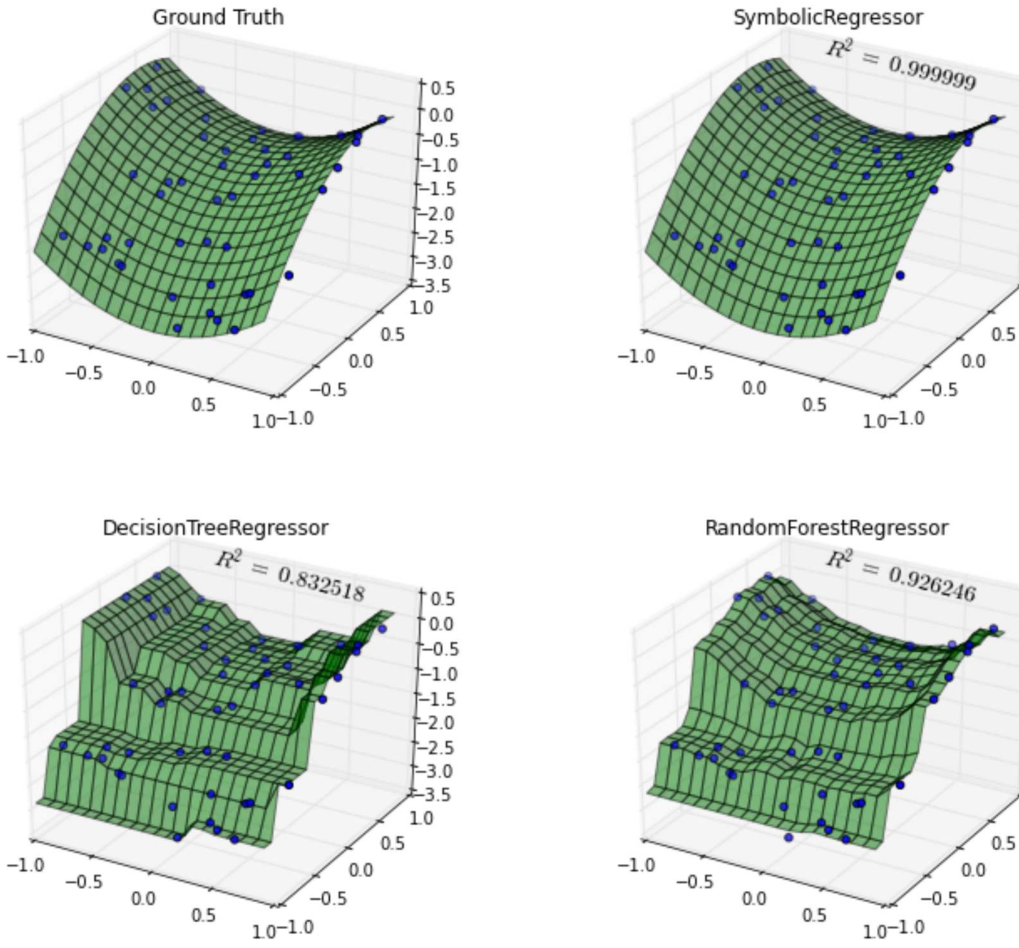
```
est_tree = DecisionTreeRegressor()
est_tree.fit(X_train, y_train)
est_rf = RandomForestRegressor()
est_rf.fit(X_train, y_train)
```

Out[6]:

```
RandomForestRegressor(bootstrap=True, criterion='mse', max_depth=None,
           max_features='auto', max_leaf_nodes=None, min_samples_leaf=1
           min_samples_split=2, min_weight_fraction_leaf=0.0,
           n_estimators=10, n_jobs=1, oob_score=False, random_state=Non
           verbose=0, warm_start=False)
```

In [7]:

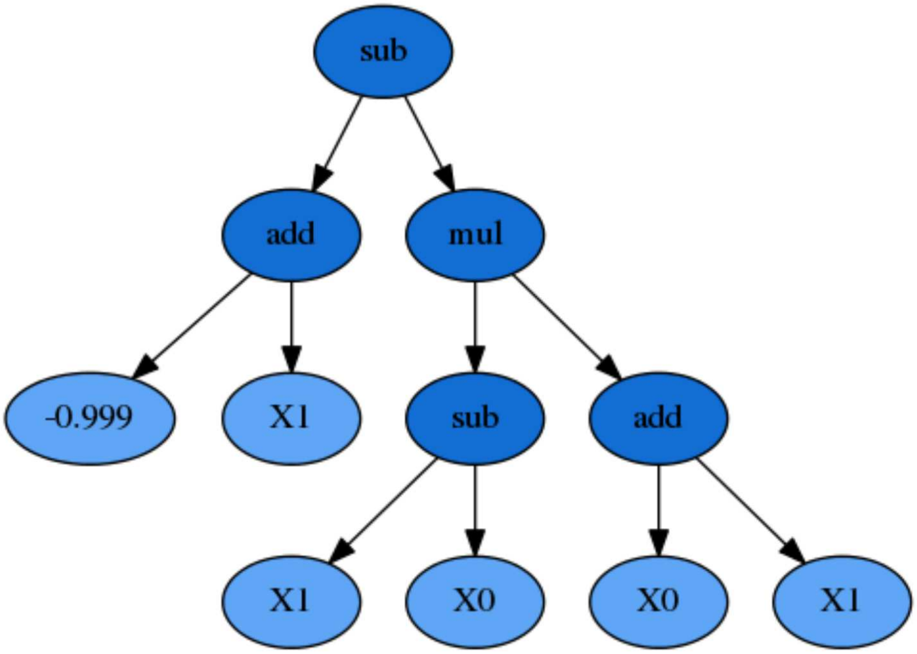
```
y_gp = est_gp.predict(np.c_[x0.ravel(), x1.ravel()]).reshape(x0.shape)
score_gp = est_gp.score(X_test, y_test)
y_tree = est_tree.predict(np.c_[x0.ravel(), x1.ravel()]).reshape(x0.shape
score_tree = est_tree.score(X_test, y_test)
y_rf = est_rf.predict(np.c_[x0.ravel(), x1.ravel()]).reshape(x0.shape)
score_rf = est_rf.score(X_test, y_test)

fig = plt.figure(figsize=(12, 10))

for i, (y, score, title) in enumerate([(y_truth, None, "Ground Truth"),
                                       (y_gp, score_gp, "SymbolicRegresso
                                       (y_tree, score_tree, "DecisionTree
                                       (y_rf, score_rf, "RandomForestRegr

    ax = fig.add_subplot(2, 2, i+1, projection='3d')
    ax.set_xlim(-1, 1)
    ax.set_ylim(-1, 1)
    surf = ax.plot_surface(x0, x1, y, rstride=1, cstride=1, color='green'
    points = ax.scatter(X_train[:, 0], X_train[:, 1], y_train)
    if score is not None:
        score = ax.text(-.7, 1, .2, "$R^2 =\/ %.6f$" % score, 'x', fontsi
    plt.title(title)

plt.show()
```



In [8]:

```
graph = pydotplus.graphviz.graph_from_dot_data(est_gp._program.export_gra
Image(graph.create_png())
```

Out[8]:



In [9]:

```
print est_gp._program.parents
```

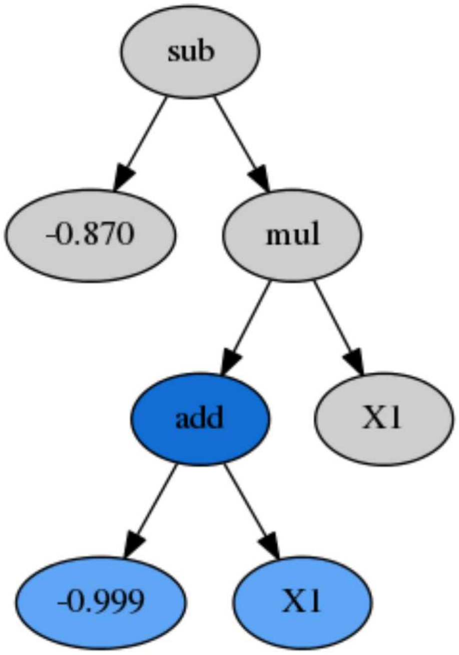
```
{'donor_nodes': [0, 1, 2, 6], 'parent_idx': 374, 'parent_nodes': [1, 2,
```

In [10]:

```
idx = est_gp._program.parents['donor_idx']
fade_nodes = est_gp._program.parents['donor_nodes']
print est_gp._programs[-2][idx]
print 'Fitness:', est_gp._programs[-2][idx].fitness_
graph = est_gp._programs[-2][idx].export_graphviz(fade_nodes=fade_nodes)
graph = pydotplus.graphviz.graph_from_dot_data(graph)
Image(graph.create_png())
```

```
sub(-0.870, mul(add(-0.999, X1), X1))
Fitness: 0.314137741318
```

Out[10]:

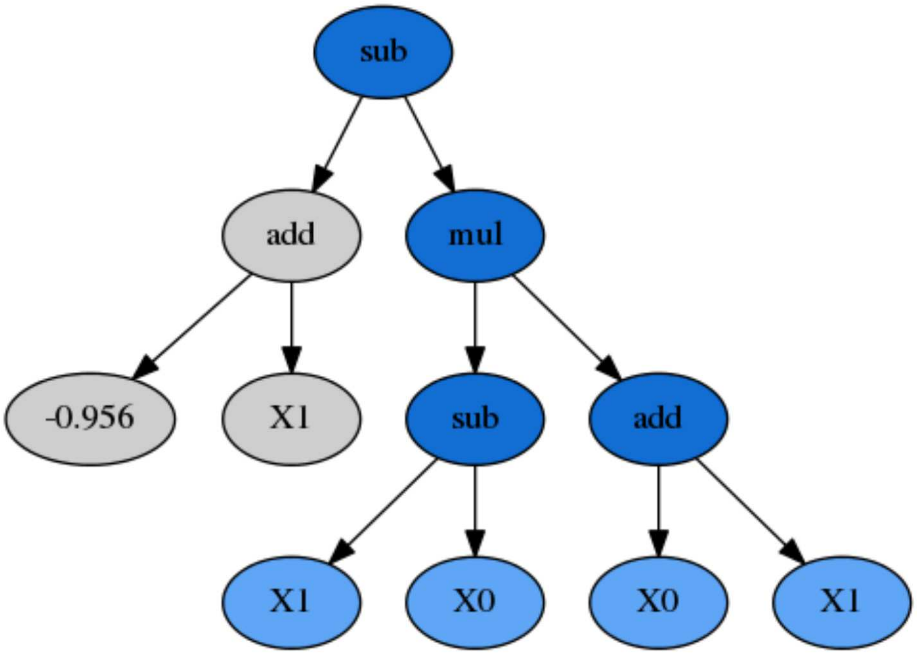


In [11]:

```
idx = est_gp._program.parents['parent_idx']
fade_nodes = est_gp._program.parents['parent_nodes']
print est_gp._programs[-2][idx]
print 'Fitness:', est_gp._programs[-2][idx].fitness_
graph = est_gp._programs[-2][idx].export_graphviz(fade_nodes=fade_nodes)
graph = pydotplus.graphviz.graph_from_dot_data(graph)
Image(graph.create_png())
```

```
sub(add(-0.956, X1), mul(sub(X1, X0), add(X0, X1)))
Fitness: 0.15361256297
```

Out[11]:



Example 2: Symbolic Transformer

In [12]:

```
from gplearn.genetic import SymbolicTransformer
from sklearn.utils import check_random_state
from sklearn.datasets import load_boston
import numpy as np
```

In [13]:

```
rng = check_random_state(0)
boston = load_boston()
perm = rng.permutation(boston.target.size)
boston.data = boston.data[perm]
boston.target = boston.target[perm]
```

In [14]:

```
from sklearn.linear_model import Ridge
est = Ridge()
est.fit(boston.data[:300, :], boston.target[:300])
print est.score(boston.data[300:, :], boston.target[300:])
```

```
0.759145222183
```

In [15]:

```
function_set = ['add', 'sub', 'mul', 'div', 'sqrt', 'log',
                'abs', 'neg', 'inv', 'max', 'min']
gp = SymbolicTransformer(generations=20, population_size=2000,
                         hall_of_fame=100, n_components=10,
                         function_set=function_set,
                         parsimony_coefficient=0.0005,
                         max_samples=0.9, verbose=1,
                         random_state=0, n_jobs=3)
gp.fit(boston.data[:300, :], boston.target[:300])

gp_features = gp.transform(boston.data)
new_boston = np.hstack((boston.data, gp_features))

est = Ridge()
est.fit(new_boston[:300, :], boston.target[:300])
print
print est.score(new_boston[300:, :], boston.target[300:])
```

```
    |    Population Average   |           Best Individual
---- ------------------------- ----------------------------------------
 Gen   Length          Fitness   Length          Fitness      OOB Fitnes
   0    11.04   0.339498855737        3   0.827183303904   0.54113453898
   1     6.76   0.595607349765        8   0.844142294401   0.57316889160
   2     5.24   0.720496338383        8   0.837040776431   0.80378332882
   3     5.42    0.73925734877        5   0.859489370651   0.58081322331
   4     6.94   0.724145477149        5   0.851564721312   0.51582982990
   5     8.75   0.706072480163       12   0.862081380781   0.46462035350
   6     9.43    0.72277984526       18     0.8665540822   0.55189896731
   7     9.81   0.728222217883        7   0.869930319583   0.69478073069
   8    10.34   0.732589362714       12   0.869313590585   0.44810733828
   9    11.16   0.734340696331       17   0.883909797276   0.27070156172
  10    12.16   0.729281362528       16   0.874698247831   0.67463606830
  11    12.46   0.737088899817       16   0.894847045579   0.51845215368
  12    13.29   0.739501531533       12   0.887976166981   0.35749228361
  13    14.63   0.741643980373       26   0.879131892265   0.65434837477
  14    14.96   0.739061407427       10   0.889673804666    0.6479108750
  15     14.8   0.744507271997        7   0.884463701515   0.59022126609
  16    13.82   0.746421818109        9   0.879741752097   0.54779233130
  17    12.74   0.741150864918        9   0.883680241981   0.65390771928
  18    12.67   0.744074323927       13   0.891438924283   0.62596678113
  19    12.31   0.754357486199        7   0.882399412561   0.61876117325

0.853618353633
```

Example 3: Customizing your programs

In [16]:

```
from gplearn.functions import make_function
```

In [17]:

```
def logic(x1, x2, x3, x4):
    return np.where(x1 > x2, x3, x4)

logical = make_function(function=logic,
                        name='logical',
                        arity=4)
```

In [18]:
```
function_set = ['add', 'sub', 'mul', 'div', logical]
gp = SymbolicTransformer(generations=2, population_size=2000,
                         hall_of_fame=100, n_components=10,
                         function_set=function_set,
                         parsimony_coefficient=0.0005,
                         max_samples=0.9, verbose=1,
                         random_state=0, n_jobs=3)
```

In [19]:
```
gp.fit(boston.data[:300, :], boston.target[:300])
```

```
    |    Population Average   |             Best Individual
---- ------------------------- ----------------------------------------
 Gen   Length          Fitness   Length          Fitness      OOB Fitnes
   0    55.28   0.295669391599        3   0.807806854954   0.75299856080
   1    10.37   0.532043054645        7    0.81020058391    0.6487032578
```

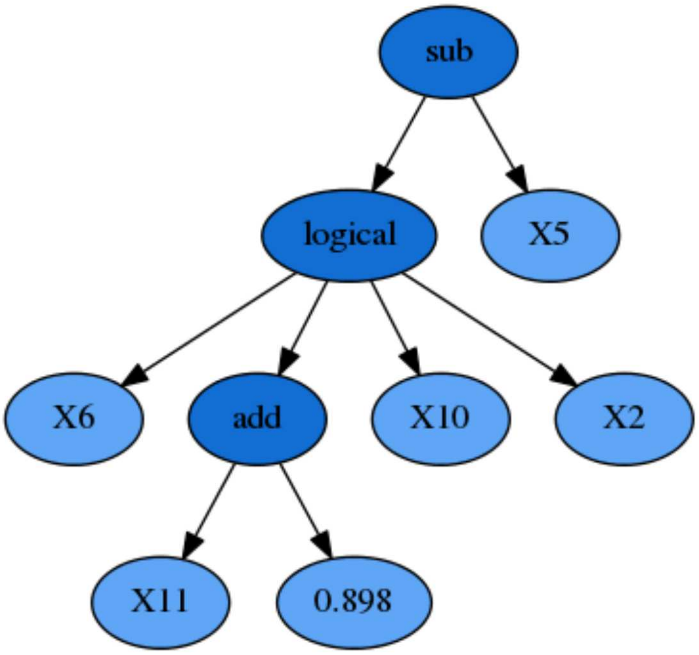
Out[19]:
```
SymbolicTransformer(const_range=(-1.0, 1.0),
          function_set=['add', 'sub', 'mul', 'div', <gplearn.functions._
          generations=2, hall_of_fame=100, init_depth=(2, 6),
          init_method='half and half', max_samples=0.9, metric='pearson
          n_components=10, n_jobs=3, p_crossover=0.9,
          p_hoist_mutation=0.01, p_point_mutation=0.01,
          p_point_replace=0.05, p_subtree_mutation=0.01,
          parsimony_coefficient=0.0005, population_size=2000,
          random_state=0, stopping_criteria=1.0, tournament_size=20,
          verbose=1)
```

In [20]:
```
print gp._programs[0][906]
```

```
sub(logical(X6, add(X11, 0.898), X10, X2), X5)
```

In [21]:
```
graph = gp._programs[0][906].export_graphviz()
graph = pydotplus.graphviz.graph_from_dot_data(graph)
Image(graph.create_png())
```

Out[21]:



In [ ]: