decision_tree

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In [3]:
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# load the data

import numpy as np
import matplotlib.pyplot as plt
import matplotlib.cm as cm
import math as m
%matplotlib inline

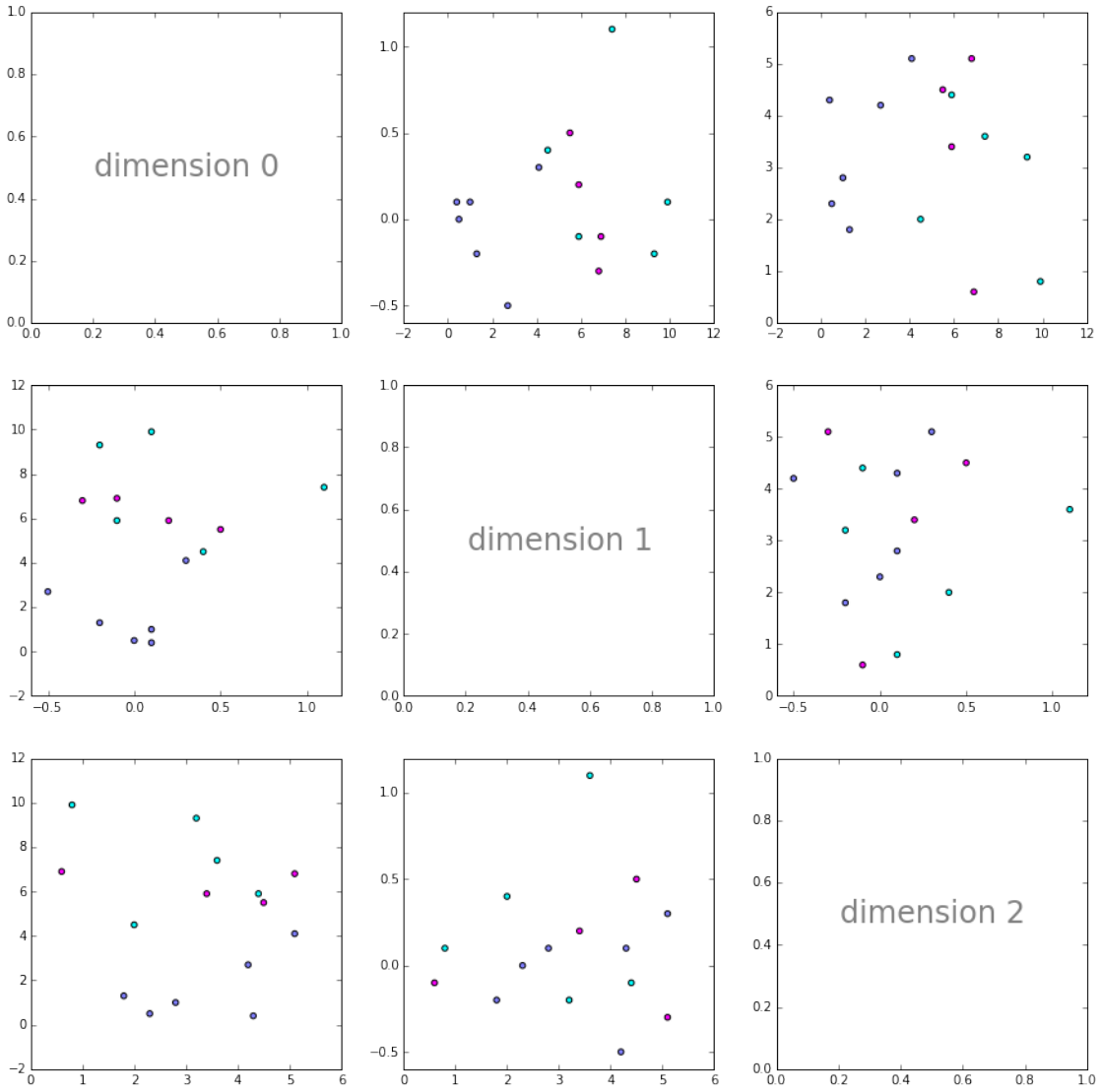
data = np.genfromtxt('../homework03.csv', delimiter=',', skip_header=1)

X = data[:,:3]
Z = data[:,3]
```

In [10]:
```
# plot the data

fig, axes = plt.subplots(3,3, figsize=(15,15))

for i in range(3):
    for j in range(3):
        if i != j:
            axes[i,j].scatter(X[:,i], X[:,j], c=Z, cmap=cm.cool)
        else:
            axes[i,j].text(0.5, 0.5, 'dimension %d' % i,
                           ha='center', va='center', size=24, alpha=.5)
```



In [4]:
```
# build a decision tree using the data

import itertools

def gini_index(labels, label_values):
    if labels.size == 0:
        return 0
    else:
        n_label = np.sum(labels[:, np.newaxis] == label_values, axis=0)
        return 1 - np.sum(n_label**2)/np.sum(n_label)**2


class DecisionTreeNode:
    def __init__(self, X, Z, depth=np.infty):
        #print('creating node with a dataset of size %d (%d levels remaining)' % (X.shape[0], d
        self.X = X
```

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        self.Z = Z
        self.left = None
        self.right = None
        self.split_pos = None
        self.n = Z.shape[0]
        self.depth = depth
        self.split()

    def gini(self):
        if self.right is None:
            return gini_index(self.Z, list(set(self.Z)))
        else:
            return (self.right.gini()*self.right.n + self.left.gini()*self.left.n) / self.n

    def get_cut_positions(self):
        s = np.sort( self.X, axis=0 )
        return (s[1:] + s[:-1]) / 2

    def get_labels(self):
        return list(set(self.Z))

    def is_pure(self):
        return len(self.get_labels()) == 1

    def get_label_counts(self):
        ls = self.get_labels()
        n_label = np.sum(self.Z[:, np.newaxis] == ls, axis=0)
        return { l:n for (l,n) in zip(ls,n_label) }

    def split(self):
        if self.is_pure():
            print('node is pure! refusing to split...')
            return
        if self.depth <= 0:
            print('reached maximum depth! refusing to split...')
            return

        label_values = self.get_labels()
        cuts = self.get_cut_positions()
        zz = cuts[:,:,np.newaxis] < self.X.T
        indices = np.array([
                [ (  gini_index(self.Z[ zz[i,j,:]], label_values)*np.sum( zz[i,j,:])
                   + gini_index(self.Z[~zz[i,j,:]], label_values)*np.sum(~zz[i,j,:])
                  )
                  for j in range(zz.shape[1])
                ]
                for i in range(zz.shape[0])
            ])
        min_index = np.argmin(indices)
        split_dim = min_index % indices.shape[1]
        split_dest = min_index // indices.shape[1]
        self.split_pos = (split_dim , cuts[split_dest, split_dim])
        mask = zz[split_dest,split_dim,:]
        # put all elements greater than the splitting boundary into the left node
```

```
            self.left = DecisionTreeNode(self.X[mask], self.Z[mask], self.depth-1)
            # all others in the right node
            self.right = DecisionTreeNode(self.X[~mask], self.Z[~mask], self.depth-1)
            return

        def subtree_to_str(self, d=0):
            res = self.node_to_str(d)
            if self.left is not None:
                res += '\n'.join(['|' + l for l in itertools.chain(
                            self.left.subtree_to_str(d+1).split('\n'),
                            self.right.subtree_to_str(d+1).split('\n'))
                ])

            return res

        def node_to_str(self, d=0):
            res = ''
            if self.split_pos is not None:
                res = ('depth: %d -- X%s > %.2f' % (d, chr(ord('0') + self.split_pos[0] + 1),
                                                    self.split_pos[1]))
            else:
                res = ('depth: %d -- leaf' % d)
            res += ' (gini: %.2f)\n' % self.gini()
            nl = self.get_label_counts()
            for l in sorted(nl.keys()):
                res += ('\t%s: %f%%\n' % (str(l), 100*nl[l]/self.n))
            return res


    class DecisionTree:
        def __init__(self, X, Z, max_depth=np.infty):
            self.X = X
            self.Z = Z
            self.max_depth = max_depth
            self.root = DecisionTreeNode(X,Z,max_depth)

        def gini_index(self):
            return self.root.gini_index()

        def print_tree(self):
            print('DFS traversal of the tree:')
            print(self.root.subtree_to_str(0))
```

In [5]:
```
T = DecisionTree(X,Z.astype(int),2)
print(30 * '=' + '\n')
T.print_tree()
```

```
node is pure! refusing to split...
reached maximum depth! refusing to split...
node is pure! refusing to split...
==============================

DFS traversal of the tree:
depth: 0 -- X1 > 4.30 (gini: 0.18)
        0: 33.333333%
```

```
        1: 40.000000%
        2: 26.666667%
|depth: 1 -- X_1 > 7.15 (gini: 0.30)
|        0: 55.555556%
|        2: 44.444444%
||depth: 2 -- leaf (gini: 0.00)
||        0: 100.000000%
||
||depth: 2 -- leaf (gini: 0.44)
||        0: 33.333333%
||        2: 66.666667%
||
|depth: 1 -- leaf (gini: 0.00)
|        1: 100.000000%
|
```