PART B - Classification

In [2]:
```
%matplotlib inline
import matplotlib.pyplot as plt
import numpy as np
import utils
import random
import os
import collections
import numpy
from sklearn import svm, tree
from sklearn.feature_extraction.text import TfidfVectorizer
from sklearn.decomposition import TruncatedSVD
from IPython.core.display import display, HTML
```

In [3]:
```
# Load dataset from saved file
DATASET_NAME = 'broad'
dataset = utils.load_from_json('%s.json' % DATASET_NAME)
N = len(dataset[dataset.keys()[0]]) # Number of sounds per class
CLASS_NAMES = dataset.keys()
print 'Loaded dataet "%s" (%i classes, %i sounds per class)' % (DATASET_
NAME, len(dataset.keys()), N)
```

```
Loaded dataet "broad" (3 classes, 100 sounds per class)
```

In [4]:
```
# Set configuration parameters (to be used below)
NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR = 10 # Maximum number of dimensio
ns for the feature vector.
CLASSIFIER_TYPE = 'tree' # Use 'svm' or 'tree'
PERCENTAGE_OF_TRAINING_DATA = 0.5 # Percentage of sounds that will be us
ed for training (others are for testing)
MAX_INPUT_TAGS_FOR_TESTING = 50 # Use a big number to "omit" this parame
ter and use as many tags as originally are in the sound
DESCRIPTORS = False
NO_KEYWORDS = ['http', 'rel="nofollow"', 'href', 'https', 'sound' , 'rec
orded', 'This', 'sounds']
```

3) Define vector space

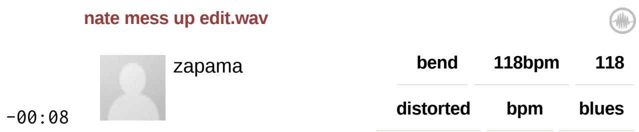
In [5]:
```
def build_tag_vector_space(n_dimensions, dataset, class_names):
    # Get all tags in the dataset (the vocabulary)
    all_tags = list()
    for class_name in class_names:
        class_tags = utils.get_all_tags_from_class(class_name, dataset)
        all_tags += class_tags

    all_tags = [tag for tag in all_tags if tag not in NO_KEYWORDS]
    # Filter out tags with less frequency (get only top N tags)
    most_common_tags = [tag for tag, count in collections.Counter(all_ta
gs).most_common(n_dimensions)]
    filtered_tags = [tag for tag in most_common_tags if tag in all_tags]

    # Build our prototype feature vector (unique list of tags), and prin
t first 10 tags
    prototype_feature_vector = list(set(filtered_tags))
    print 'Created prototype feature vector with %i dimensions (original
ly %i dimensions)' % (
        len(prototype_feature_vector), len(set(all_tags)))
    print 'Prototype vector tags (sorted by occurrence in filtered_tags)
:', ', '.join([tag for tag in filtered_tags[:10]]),
    print '...\n' if len(filtered_tags) > 10 else '\n'
    return prototype_feature_vector

def build_keyword_vector_space(n_dimensions, dataset, class_names):
    # Get all keywords in the dataset (the vocabulary)
    all_keywords = list()
    for class_name in class_names:
        class_keywords = utils.get_all_keywords_from_class(class_name, d
ataset)
        all_keywords += class_keywords

    all_keywords = [k for k in all_keywords if k not in NO_KEYWORDS]
    # Filter out keywords with less frequency (get only top N keywords)
    most_common_keywords = [k for k, count in collections.Counter(all_ke
ywords).most_common(n_dimensions)]
    filtered_keywords = [k for k in most_common_keywords if k in all_key
words]

    # Build our prototype feature vector (unique list of keywords), and
print first 10 keywords
    prototype_feature_vector = list(set(filtered_keywords))
    print 'Created prototype feature vector with %i dimensions (original
ly %i dimensions)' % (
        len(prototype_feature_vector), len(set(all_keywords)))
    print 'Prototype vector keywords (sorted by occurrence in filtered_k
eywords):', ', '.join([k for k in filtered_keywords[:10]]),
    print '...\n' if len(filtered_keywords) > 10 else '\n'
    return prototype_feature_vector


prototype_feature_vector_tags = build_tag_vector_space(
    n_dimensions=NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR,
    dataset=dataset,
    class_names=CLASS_NAMES,
)

prototype_feature_vector_keywords = (build_keyword_vector_space(
    n_dimensions=NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR,
    dataset=dataset,
    class_names=CLASS_NAMES,
))

prototype_feature_vector = list(set(prototype_feature_vector_tags) | set
(prototype_feature_vector_keywords) - set(NO_KEYWORDS))
print 'Final feature vector size ' + str(len(prototype_feature_vector))
+ ' features: '+ str(prototype_feature_vector)
```

```
Created prototype feature vector with 10 dimensions (originally 777 dimen
sions)
Prototype vector tags (sorted by occurrence in filtered_tags): guitar, el
ectric, acoustic, distorted, chord, distortion, Guitar, rock, loop, riff

Created prototype feature vector with 10 dimensions (originally 1006 dime
nsions)
Prototype vector keywords (sorted by occurrence in filtered_keywords): gu
itar, electric guitar, acoustic guitar, Recorded, played, Guitar, loop, p
laying, distorted, distortion

Final feature vector size 15 features: [u'Guitar', u'chord', u'electric',
u'acoustic guitar', u'played', u'electric guitar', u'rock', u'Recorded',
u'distortion', u'guitar', u'riff', u'distorted', u'acoustic', u'playing',
u'loop']
```

4) Project documents in the vector space

In [6]:

```python
# Example of getting feature vector from tags list...
random_sound = random.choice(dataset[random.choice(dataset.keys())])
random_sound_tags = random_sound['tags']
random_sound_keywords = random_sound['keywords']
random_sound_features = list(set(random_sound_tags) | set(random_sound_k
eywords) - set(NO_KEYWORDS))
random_sound_feature_vector = utils.get_feature_vector_from_tags(random_
sound_features, prototype_feature_vector)

display(HTML(utils.get_sound_embed_html(random_sound['id'])))
print 'Chosen sound has features:', ', '.join(random_sound_features)
html = '<table><tr><td>'
html += '</td><td>'.join([f for f in prototype_feature_vector])
html += '</td></tr><tr><td>'
html += '</td><td>'.join(['x' if prototype_feature_vector[count] in rand
om_sound_features else ''
                          for count, item in enumerate(random_sound_feat
ure_vector)])
html += '</td></tr></table>'
display(HTML(html))
```




```
Chosen sound has features: chopped, sample, 118bpm, electric, Nate, level
, BPM, distorted, bpm, 118, guitar, riff, bend, rock, loops, overdrive, b
lues, loop
```

Guitar	chord	electric	acoustic guitar	played	electric guitar	rock	Recorded	distortion	guitar	riff	distorted	acous
		x				x			x	x	x	

5) Define train and testing set

In [7]:
```
def create_train_and_test_sets(dataset, class_names, n_sounds_per_class,
percentage_training_data,
                               max_input_tags_for_testing):

    n_training_sounds_per_class = int(n_sounds_per_class * percentage_tr
aining_data)
    training_set = dict()
    testing_set = dict()

    # Get 'n_training_sounds_per_class' sounds per class
    for class_name, sounds in dataset.items():
        sounds_from_class = sounds[:] # Copy the list so when we later s
huffle it does not affect the original data
        #random.shuffle(sounds_from_class)
        training_set[class_name] = sounds_from_class[:n_training_sounds_
per_class] # First sounds for training
        testing_set[class_name] = sounds_from_class[n_training_sounds_pe
r_class:] # Following sounds for testing

        # Save a trimmed version of input tags for testing sounds
        for sound in testing_set[class_name]:
            sound['tags'] = random.sample(sound['tags'], min(max_input_t
ags_for_testing, len(sound['tags'])))

    print 'Created training and testing sets with the following number o
f sounds:\n\tTrain\tTest'
    for class_name in class_names:
        training_sounds = training_set[class_name]
        testing_sounds = testing_set[class_name]
        print '\t%i\t%i\t%s' % (len(training_sounds), len(testing_sounds
), class_name)
    return training_set, testing_set

training_set, testing_set = create_train_and_test_sets(
    dataset=dataset,
    class_names=CLASS_NAMES,
    n_sounds_per_class=N,
    percentage_training_data=PERCENTAGE_OF_TRAINING_DATA,
    max_input_tags_for_testing=MAX_INPUT_TAGS_FOR_TESTING,
)
```

```
Created training and testing sets with the following number of sounds:
        Train   Test
        50      50      Distorted Guitar
        50      50      Electric Guitar
        50      50      Acoustic Guitar
```

6) Train classifier

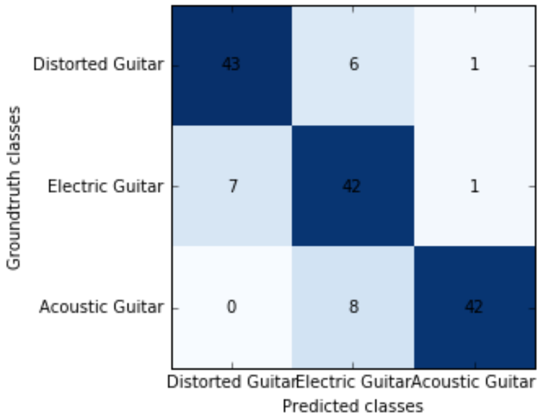
In [8]:
```
def build_tag_feature_vector(sound):
    features = list(set(sound['tags']) | set(sound['keywords']) - set(NO
_KEYWORDS))
    tag_features = utils.get_feature_vector_from_tags(features, prototyp
e_feature_vector)
    return np.concatenate([[], tag_features])

def train_classifier(training_set, classifier_type, class_names, dataset
_name, feature_vector_func,
                     feature_vector_dimension_labels=None):

    # Prepare data for fitting classifier (as sklearn classifiers requir
e)
    classes_vector = list()
    feature_vectors = list()
    for class_name, sounds in training_set.items():
        for count, sound in enumerate(sounds):
            # Use index of class name in CLASS_NAMES as numerical value
(classifier internally represents
            # class label as number)
            classes_vector.append(CLASS_NAMES.index(class_name))
            feature_vector = feature_vector_func(sound)
            if DESCRIPTORS:
                try:
                    mfcc = sound['analysis']['lowlevel']['mfcc']['mean']
                    mfcc_norm = [float(i)/sum(mfcc) for i in mfcc[1:]]
                    feature_vector = np.append(feature_vector, mfcc_norm
)
                except:
                    feature_vector = np.append(feature_vector, [0,0,0,0,
0,0,0,0,0,0,0,0])
            feature_vectors.append(feature_vector)
    # Create and fit classifier
    print 'Training classifier (%s) with %i sounds...' % (CLASSIFIER_TYP
E, len(feature_vectors)),
    if classifier_type == 'svm':
        classifier = svm.LinearSVC()
        classifier.fit(feature_vectors, classes_vector)
    elif classifier_type == 'tree':
        classifier = tree.DecisionTreeClassifier(max_depth=5)
        classifier.fit(feature_vectors, classes_vector)
        # Plot classifier decision rules
        # WARNING: do not run this if tree is too big, might freeze
        out_filename = os.getcwd() + '/%s-tree.png' % dataset_name
        #utils.export_tree_as_graph(
        #    classifier, feature_vector_dimension_labels, class_names=cl
ass_names, filename=out_filename)
        #display(HTML('<h4>Learned tree:</h4><img src="%s"/>' % out_file
name))
    else:
        raise Exception('Bad classifier type!!!')
    return classifier

classifier = train_classifier(
    training_set=training_set,
    classifier_type=CLASSIFIER_TYPE,
    class_names=CLASS_NAMES,
    dataset_name=DATASET_NAME,
    feature_vector_func=build_tag_feature_vector,
    feature_vector_dimension_labels=prototype_feature_vector,
)
```

```
Training classifier (tree) with 150 sounds...
```

7) Evaluate classification

In [9]:
```
def evaluate_classifier(testing_set, classifier, class_names, feature_ve
ctor_func, show_confussing_matrix=True):
    # Test with testing set
    print '\nEvaluating with %i instances...' % sum([len(sounds) for sou
nds in testing_set.values()]),
    predicted_data = list()
    for class_name, sounds in testing_set.items():
        for count, sound in enumerate(sounds):
            feature_vector = feature_vector_func(sound)
            if DESCRIPTORS:
                try:
                    mfcc = sound['analysis']['lowlevel']['barkbands']['m
ean']
                    mfcc_norm = [float(i)/sum(mfcc) for i in mfcc[1:]]
                    feature_vector = np.append(feature_vector.append, mf
cc_norm)
                except:
                    feature_vector = np.append(feature_vector, [0,0,0,0,
0,0,0,0,0,0,0,0])

            predicted_class_name = unicode(class_names[classifier.predic
t([feature_vector])[0]])
            predicted_data.append((sound['id'], class_name, predicted_cl
ass_name))
    print 'done!'

    # Compute overall accuracy
    good_predictions = len([1 for sid, cname, pname in predicted_data if
cname == pname])
    wrong_predictions = len([1 for sid, cname, pname in predicted_data i
f cname != pname])
    print '%i correct predictions' % good_predictions
    print '%i wrong predictions' % wrong_predictions
    accuracy = float(good_predictions)/(good_predictions + wrong_predict
ions)
    print 'Overall accuracy %.2f%%' % (100 * accuracy)

    if show_confussing_matrix:
        # Compute confussion matrix (further analysis)
        matrix = list()
        for class_name in CLASS_NAMES:
            predicted_classes = list()
            for sid, cname, pname in predicted_data:
                if cname == class_name:
                    predicted_classes.append(pname)
            matrix.append([predicted_classes.count(target_class) for tar
get_class in CLASS_NAMES])

        # Plot confussion matrix
        fig = plt.figure()
        plt.clf()
        ax = fig.add_subplot(111)
        ax.set_aspect(1)
        res = ax.imshow(matrix, cmap=plt.cm.Blues, interpolation='neares
t')

        for x in xrange(len(matrix)):
            for y in xrange(len(matrix)):
                ax.annotate(str(matrix[x][y]), xy=(y, x),
                            horizontalalignment='center',
                            verticalalignment='center')

        plt.xticks(range(len(class_names)), class_names)
        plt.yticks(range(len(class_names)), class_names)
        plt.xlabel('Predicted classes')
        plt.ylabel('Groundtruth classes')

        print 'Confussion matrix'
```

```
Evaluating with 150 instances... done!
127 correct predictions
23 wrong predictions
Overall accuracy 84.67%
Confussion matrix
```

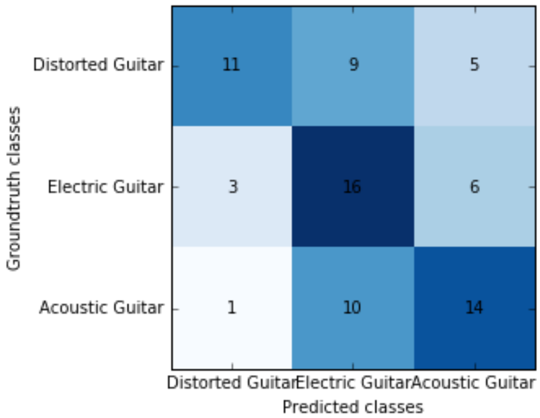



```
Out[9]: 0.8466666666666667
```

In [10]:
```
# Run the whole experiment again with other parameters

NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR = 10
PERCENTAGE_OF_TRAINING_DATA = 0.75
MAX_INPUT_TAGS_FOR_TESTING = 2

for classifier_type in ['svm', 'tree']:
    display(HTML('<h2>With %s classifier</h2>' % classifier_type.upper()
))

    prototype_feature_vector = build_tag_vector_space(
        n_dimensions=NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR,
        dataset=dataset,
        class_names=CLASS_NAMES,
    )
    training_set, testing_set = create_train_and_test_sets(
        dataset=dataset,
        class_names=CLASS_NAMES,
        n_sounds_per_class=N,
        percentage_training_data=PERCENTAGE_OF_TRAINING_DATA,
        max_input_tags_for_testing=MAX_INPUT_TAGS_FOR_TESTING,
    )
    classifier = train_classifier(
        training_set=training_set,
        classifier_type=classifier_type,
        class_names=CLASS_NAMES,
        dataset_name=DATASET_NAME,
        feature_vector_func=build_tag_feature_vector,
        feature_vector_dimension_labels=prototype_feature_vector,
    )
    evaluate_classifier(
        testing_set=testing_set,
        classifier=classifier,
        class_names=CLASS_NAMES,
        feature_vector_func=build_tag_feature_vector,
    )
```

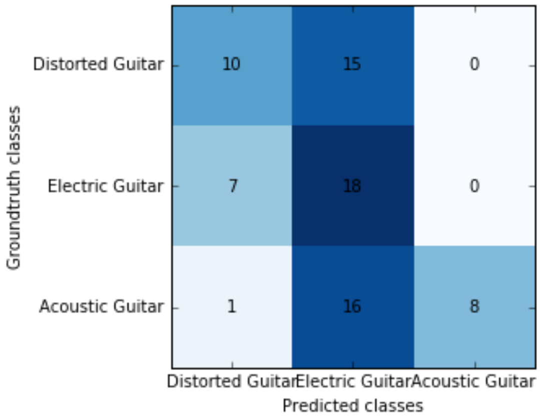
With SVM classifier

```
Created prototype feature vector with 10 dimensions (originally 777 dimen
sions)
Prototype vector tags (sorted by occurrence in filtered_tags): guitar, el
ectric, acoustic, distorted, chord, distortion, Guitar, rock, loop, riff

Created training and testing sets with the following number of sounds:
        Train   Test
        75      25      Distorted Guitar
        75      25      Electric Guitar
        75      25      Acoustic Guitar
Training classifier (tree) with 225 sounds...
Evaluating with 75 instances... done!
41 correct predictions
34 wrong predictions
Overall accuracy 54.67%
Confussion matrix
```



With TREE classifier

```
Created prototype feature vector with 10 dimensions (originally 683 dimen
sions)
Prototype vector tags (sorted by occurrence in filtered_tags): guitar, el
ectric, acoustic, distorted, chord, Guitar, rock, distortion, loop, riff

Created training and testing sets with the following number of sounds:
        Train   Test
        75      25      Distorted Guitar
        75      25      Electric Guitar
        75      25      Acoustic Guitar
Training classifier (tree) with 225 sounds...
Evaluating with 75 instances... done!
36 correct predictions
39 wrong predictions
Overall accuracy 48.00%
Confussion matrix
```



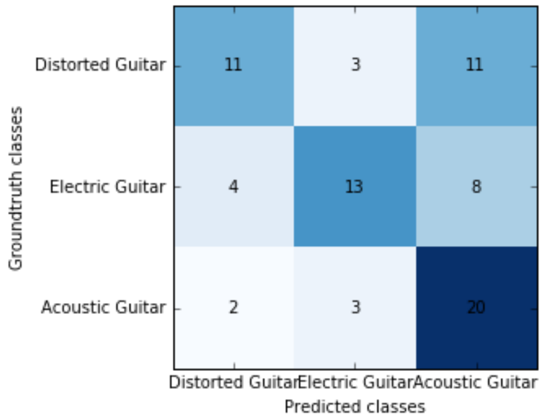
In [11]:

```
# CODE FOR GENERATING FEATURE VECTORS WITH LATENT SEMANTIC ANALYSIS

def build_latent_semantic_analysis_feature_vectors(n_dimensions, trainin
g_set, testing_set):
    # Build latent semantic analysis (LSA) matrix factors
    vectorizer = TfidfVectorizer(
        sublinear_tf=True, max_df=0.5, stop_words='english', analyzer='w
ord', max_features=50000)
    svd = TruncatedSVD(n_components=n_dimensions, n_iter=7, random_state
=42)

    # Compute LSA feature vectors for training set
    lsa_feature_vectors = list()
    lsa_feature_vectors_sound_ids = list()
    for class_name, sounds in training_set.items():
        for sound in sounds:
            lsa_feature_vectors.append(' '.join(sound['tags']))
            lsa_feature_vectors_sound_ids.append(sound['id'])
    X = vectorizer.fit_transform(lsa_feature_vectors)
    lsa_feature_vectors = svd.fit_transform(X)
    lsa_feature_vectors_dict = {sound_id:features for sound_id, features
                                in zip(lsa_feature_vectors_sound_ids, ls
a_feature_vectors)}

    # Now compute LSA feature vectors for testing set (using vectorizer
and svd learnt for training set)
    lsa_feature_vectors = list()
    lsa_feature_vectors_sound_ids = list()
    for class_name, sounds in testing_set.items():
        for sound in sounds:
            lsa_feature_vectors.append(' '.join(sound['tags']))
            lsa_feature_vectors_sound_ids.append(sound['id'])
    X = vectorizer.transform(lsa_feature_vectors)
    lsa_feature_vectors = svd.transform(X)
    lsa_feature_vectors_dict.update({sound_id:features for sound_id, fea
tures
                                     in zip(lsa_feature_vectors_sound_id
s, lsa_feature_vectors)})

    print 'Built LSA feature vectors for %i sounds!' % len(lsa_feature_v
ectors_dict)
    return lsa_feature_vectors_dict
```

In [12]:
```
# EXAMPLE EXPERIMENT USING LATENT SEMANTIC ANALYSIS

display(HTML('<h2>With Latent Semantic Analysis</h2>'))

NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR = 10
CLASSIFIER_TYPE = 'tree'
PERCENTAGE_OF_TRAINING_DATA = 0.75
MAX_INPUT_TAGS_FOR_TESTING = 2

def build_lsa_feature_vector(sound):
    lsa_features = lsa_feature_vectors_dict[sound['id']]
    return np.concatenate([[], lsa_features])

lsa_feature_vectors_dict = build_latent_semantic_analysis_feature_vector
s(
    n_dimensions=NUMBER_OF_DIMENSIONS_OF_FEATURE_VECTOR, training_set=tr
aining_set, testing_set=testing_set,)

training_set, testing_set = create_train_and_test_sets(
    dataset=dataset, class_names=CLASS_NAMES, n_sounds_per_class=N,
    percentage_training_data=PERCENTAGE_OF_TRAINING_DATA, max_input_tags
_for_testing=MAX_INPUT_TAGS_FOR_TESTING)
classifier = train_classifier(
    training_set=training_set, classifier_type=CLASSIFIER_TYPE, class_na
mes=CLASS_NAMES, dataset_name=DATASET_NAME,
    feature_vector_func=build_lsa_feature_vector,
)
evaluate_classifier(
    testing_set=testing_set, classifier=classifier, class_names=CLASS_NA
MES,
    feature_vector_func=build_lsa_feature_vector)
```

With Latent Semantic Analysis

```
Built LSA feature vectors for 291 sounds!
Created training and testing sets with the following number of sounds:
        Train   Test
        75      25      Distorted Guitar
        75      25      Electric Guitar
        75      25      Acoustic Guitar
Training classifier (tree) with 225 sounds...
Evaluating with 75 instances... done!
44 correct predictions
31 wrong predictions
Overall accuracy 58.67%
Confussion matrix
```



Out[12]: 0.5866666666666667

In [ ]: