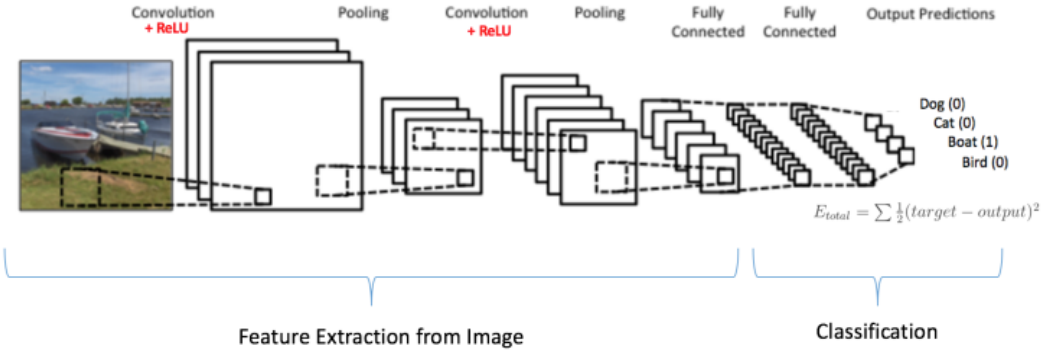
Convolutional Neural Network with TensorFlow

Lujun Jian

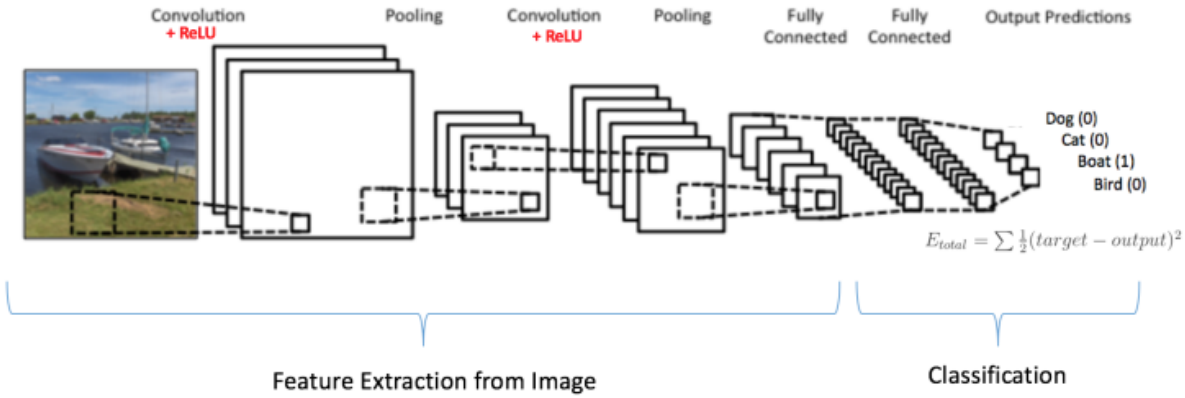
Motivation

- TensorFlow by Google
  - Open source library for mathematical computation, especially good for Machine Learning
  - Scalability - can be deployed to multiple CPUs/ GPUs
  - Data flow graph architecture
    - Node - computation/ function
    - Edges - multidimensional data (tensors)
- Convolutional Neural Network (CNN)



CNN - Supervised Learning

- Image classification with CNN - Supervised Learning
- In the training process, use backward propagation and gradient descend to update all the filter value and weights



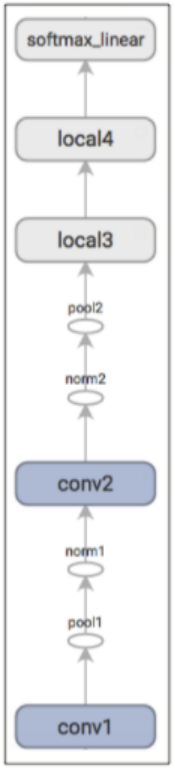
Data

- CIFAR-10
  - 60,000 32x32 colour images in 10 classes - 50,000 training data, 10,000 test data
  - Classes: airplane, automobile, bird, cat, deer, dog, frog, horse, ship, truck
  - In my project
    - 50,000 training images
    - 2,000 test images
    - Binary version of the file - each image is represented by 3073 bytes
      - 1 byte is the label: 0~9
      - 1024 byte of the red value
      - 1024 byte of the green value
      - 1024 byte of the blue value

```
<1 x label><3072 x pixel>
...
<1 x label><3072 x pixel>
```

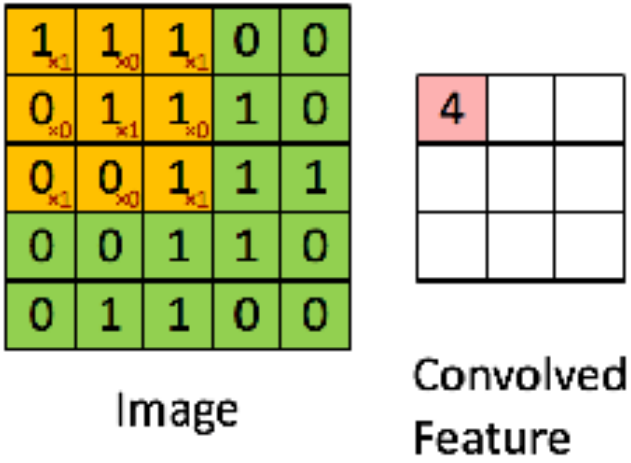
Methods - TensorFlow CNN Tutorial

Layer Name	Description
conv1	convolution and rectified linear activation.
pool1	max pooling.
norm1	local response normalization.
conv2	convolution and rectified linear activation.
norm2	local response normalization.
pool2	max pooling.
local3	fully connected layer with rectified linear activation.
local4	fully connected layer with rectified linear activation.
softmax_linear	linear transformation to produce logits.



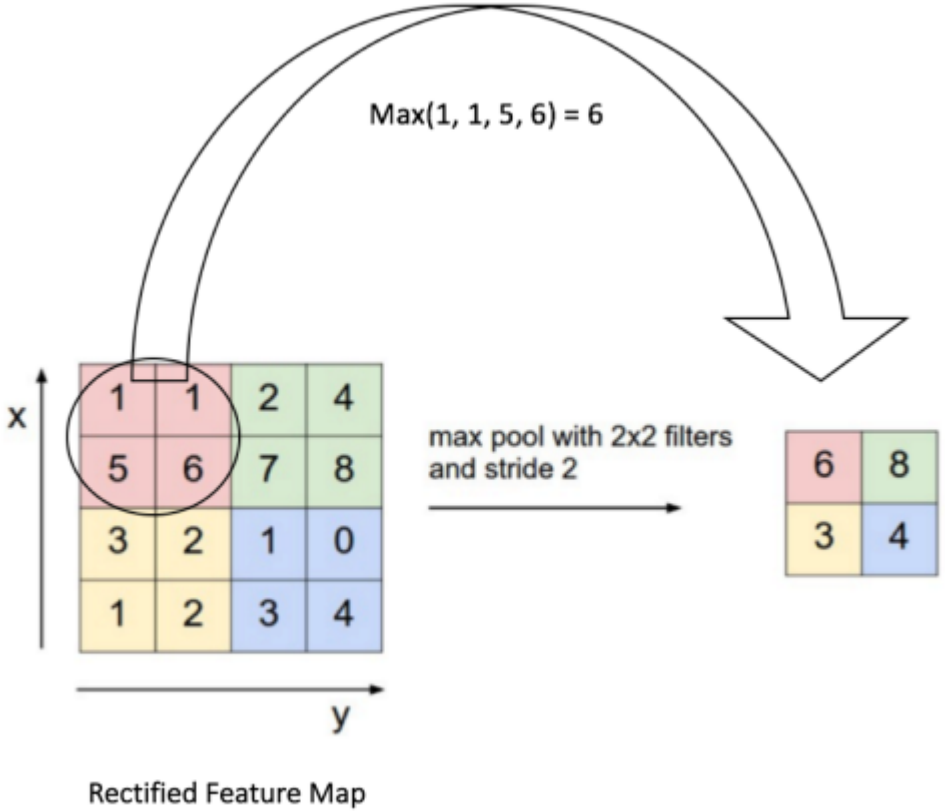
Convolution Layer

Image · Filter → Feature Map



Max Pooling Layer

Reduce dimension but retain important information

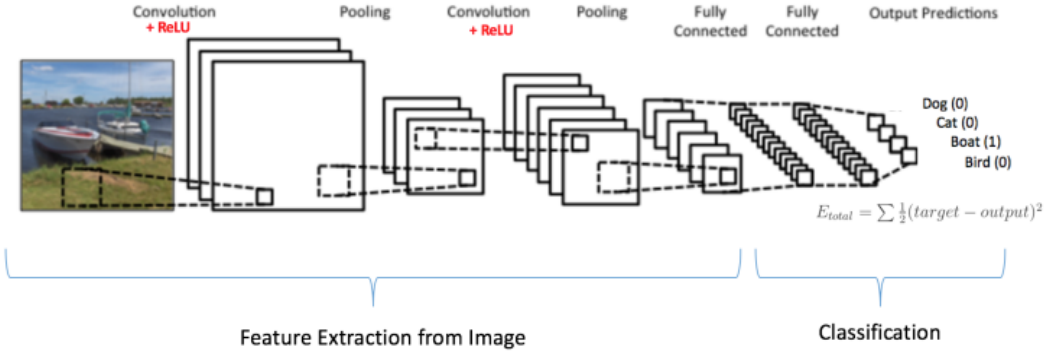


Location Response Normalization Layer

- Perform “lateral inhibition”
- Create a significant peak/ local maxima by subdue its neighbors
- Detect high frequency features with a large response to increase the sensory perception

Fully Connected Layer + Softmax

- “Fully Connected” - every neuron(computation) in the previous layer is connected to every neuron on the next layer
- To use the high-level features extracted by convolutional and pooling layers for classifying the input into the various classes
- Softmax is the multi-classes classifier function and the output probabilities will sum to one



Sample of the code

```
# conv1
with tf.variable_scope('conv1') as scope:
  kernel = _variable_with_weight_decay('weights',
                                       shape=[5, 5, 3, 64],
                                       stddev=5e-2,
                                       wd=0.0)
  conv = tf.nn.conv2d(images, kernel, [1, 1, 1, 1], padding='SAME')
  biases = _variable_on_cpu('biases', [64], tf.constant_initializer(0.0))
  pre_activation = tf.nn.bias_add(conv, biases)
  conv1 = tf.nn.relu(pre_activation, name=scope.name)
  _activation_summary(conv1)

# pool1
pool1 = tf.nn.max_pool(conv1, ksize=[1, 3, 3, 1], strides=[1, 2, 2, 1],
                       padding='SAME', name='pool1')
# norm1
norm1 = tf.nn.lrn(pool1, 4, bias=1.0, alpha=0.001 / 9.0, beta=0.75,
                  name='norm1')
```

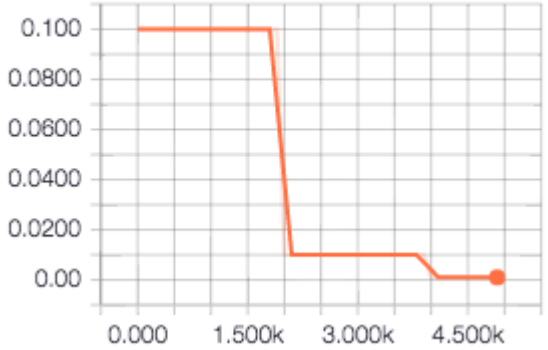
Sample of the code

```
# local3
with tf.variable_scope('local3') as scope:
  # Move everything into depth so we can perform a single matrix multiply.
  reshape = tf.reshape(pool2, [FLAGS.batch_size, -1])
  dim = reshape.get_shape()[1].value
  weights = _variable_with_weight_decay('weights', shape=[dim, 384],
                                        stddev=0.04, wd=0.004)
  biases = _variable_on_cpu('biases', [384], tf.constant_initializer(0.1))
  local3 = tf.nn.relu(tf.matmul(reshape, weights) + biases, name=scope.name)
  _activation_summary(local3)
```

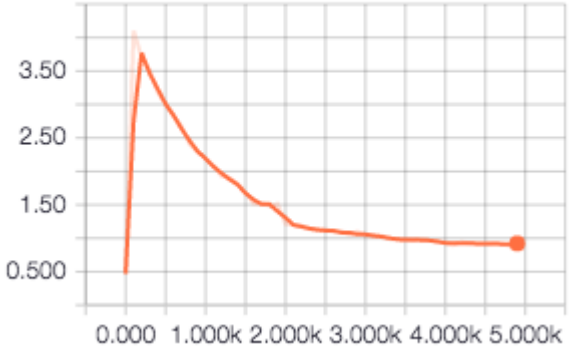
Result

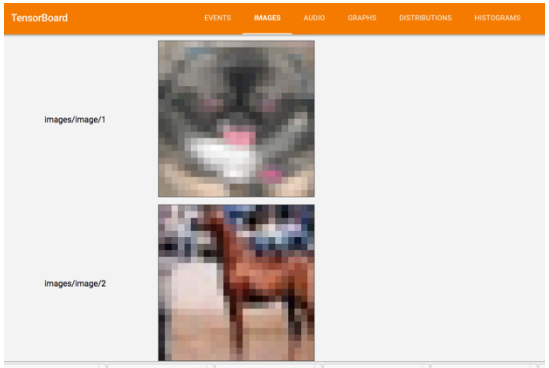
train images	max_step/ number of batches to run	batch size	num of epoch	num Epochs after learning rate decays	initial learning rate	learning rate decay factor	duration	final loss	test images	accuracy
50000	5000	128	12.8	never	0.1	0	1 hr 29 min	0.68	2000	0.75
50000	5000	128	12.8	5	0.1	0.1	1 hr 46 min	0.92	2000	0.745

learning_rate



total_loss





Interpretation & Future Works

- Goal: Increase the accuracy in limited steps
- Compare the accuracies with different params and architectures
  - Initial learning rate
  - Learning rate decay rate (*)
  - Number of epoch after learning rate starts decaying
  - Number of convolutional layers
  - Max steps
- TensorBoard - visualization of the learning (*)

Thank you!

Q & A!

Detecting Musical Patterns Using HMMs

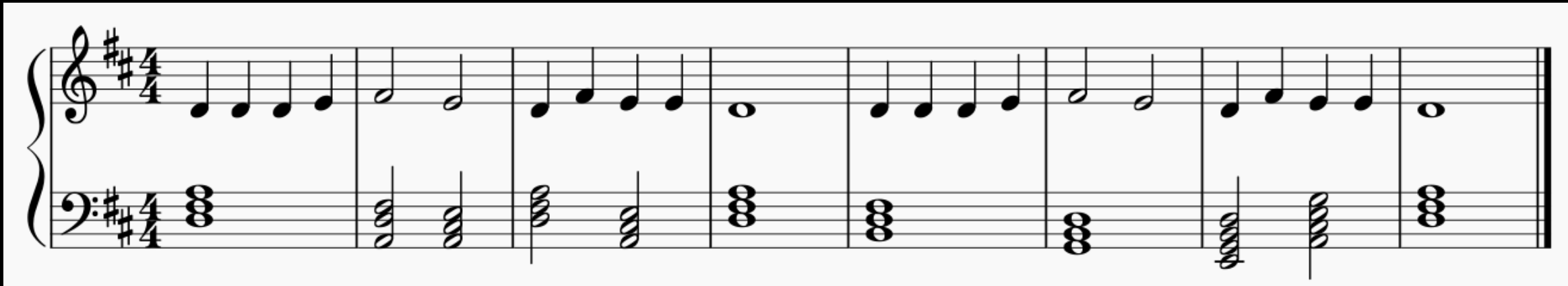
Youyou Tian

CSC 390

Motivation

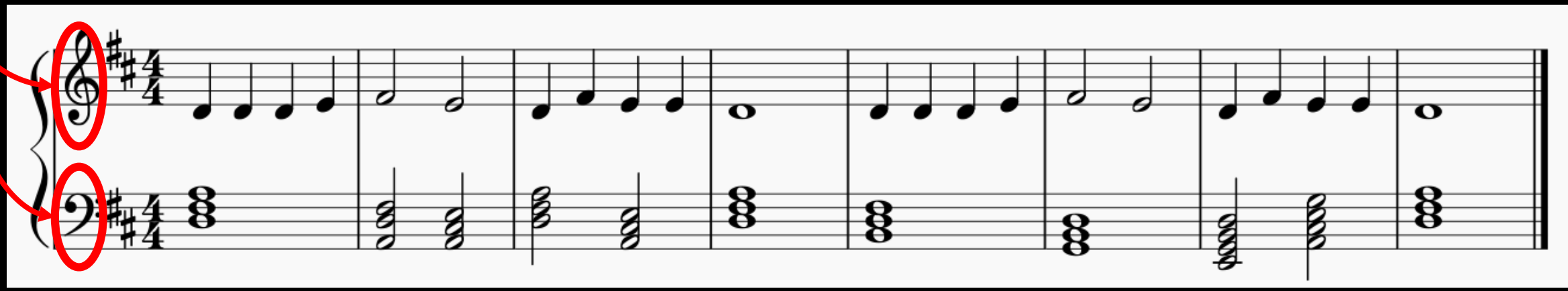
- Fast growth in digital music collection
- With this large span of music genres, how can listeners effectively categorize these music collections?

Musical Terminology

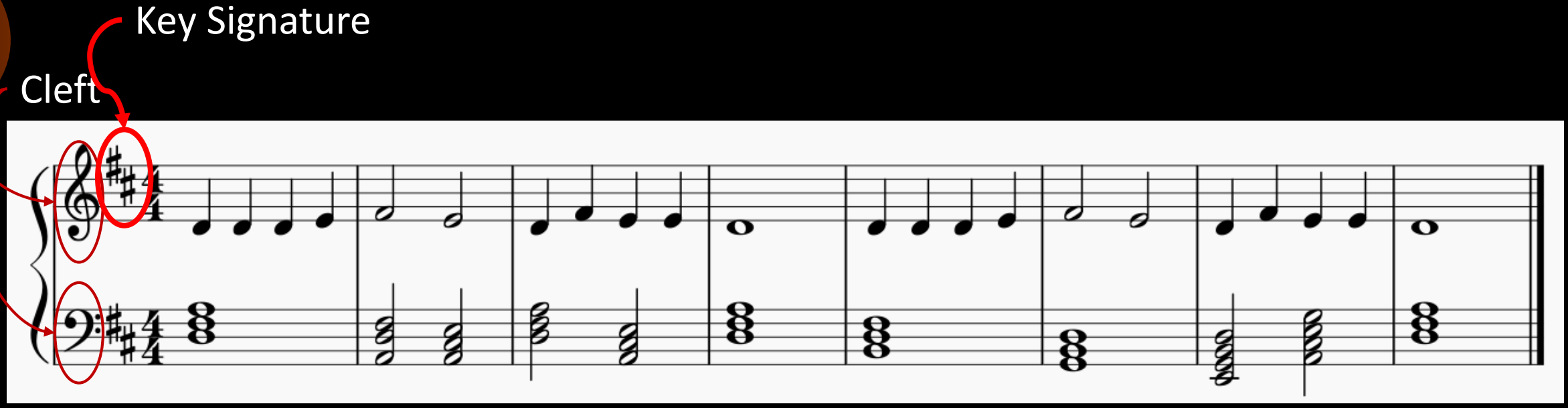


Musical Terminology

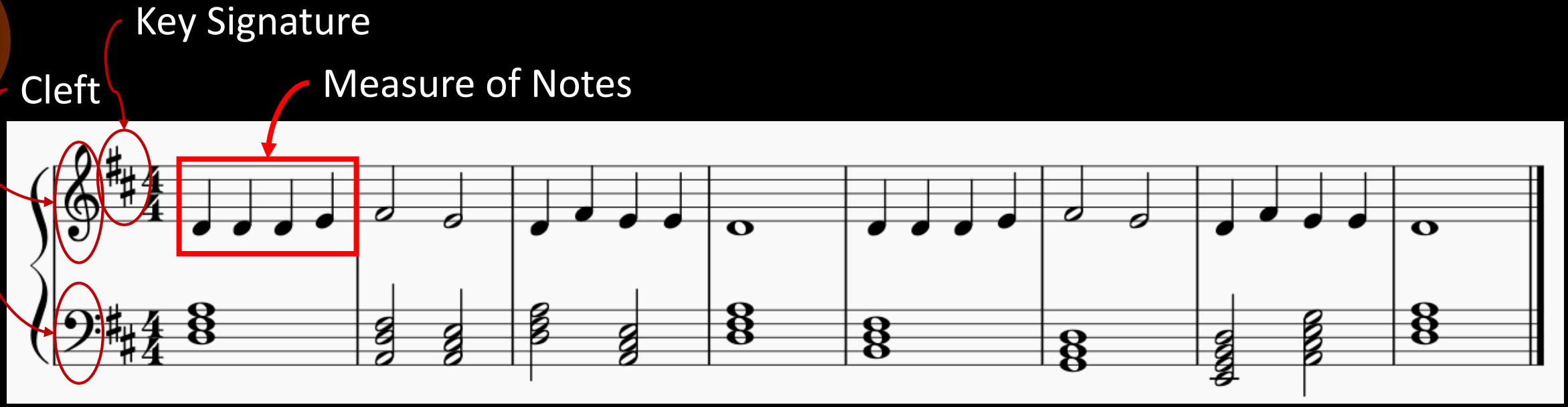
Cleft



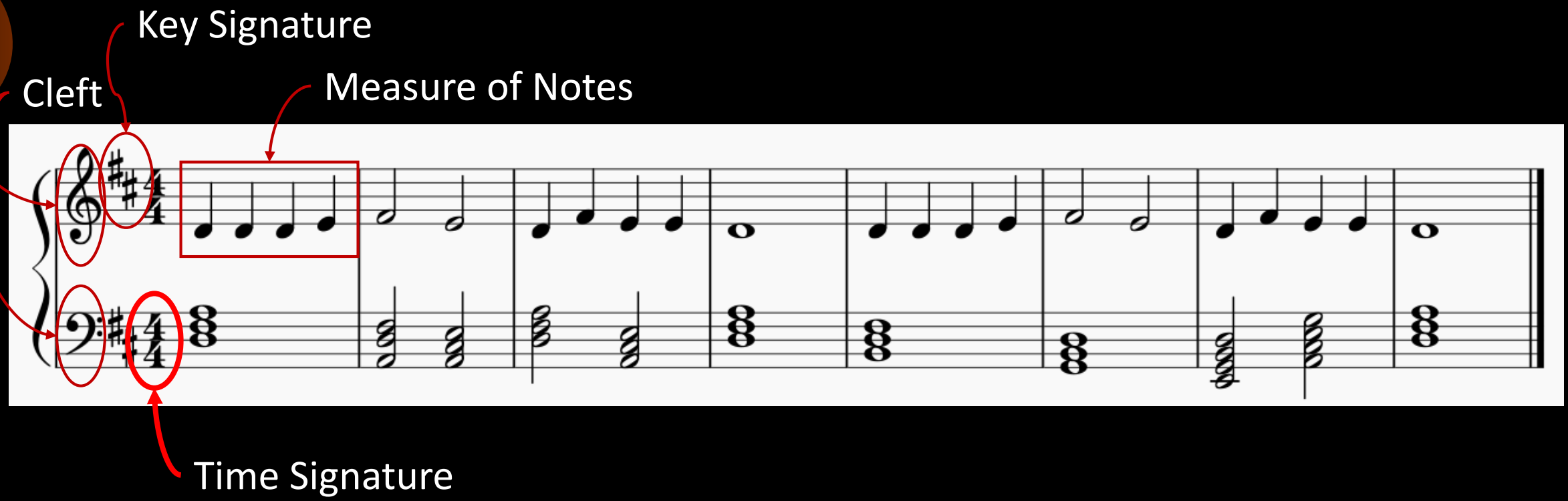
Musical Terminology



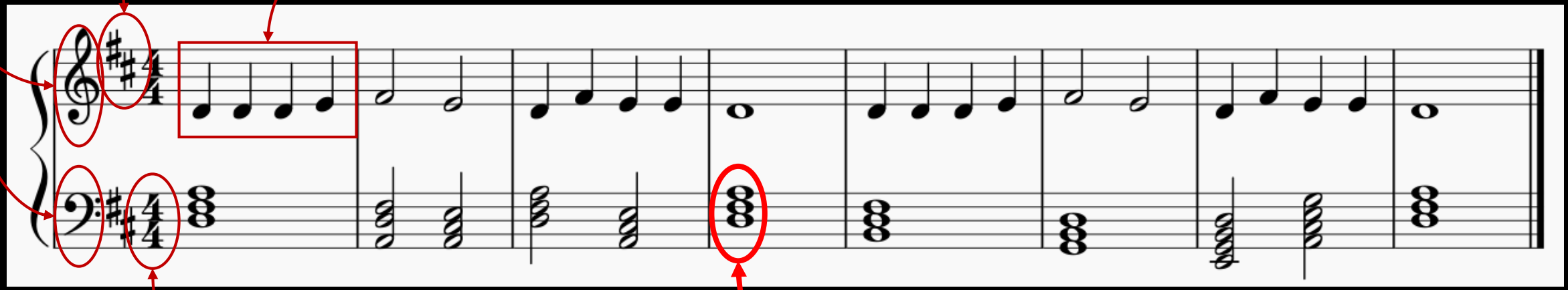
Musical Terminology



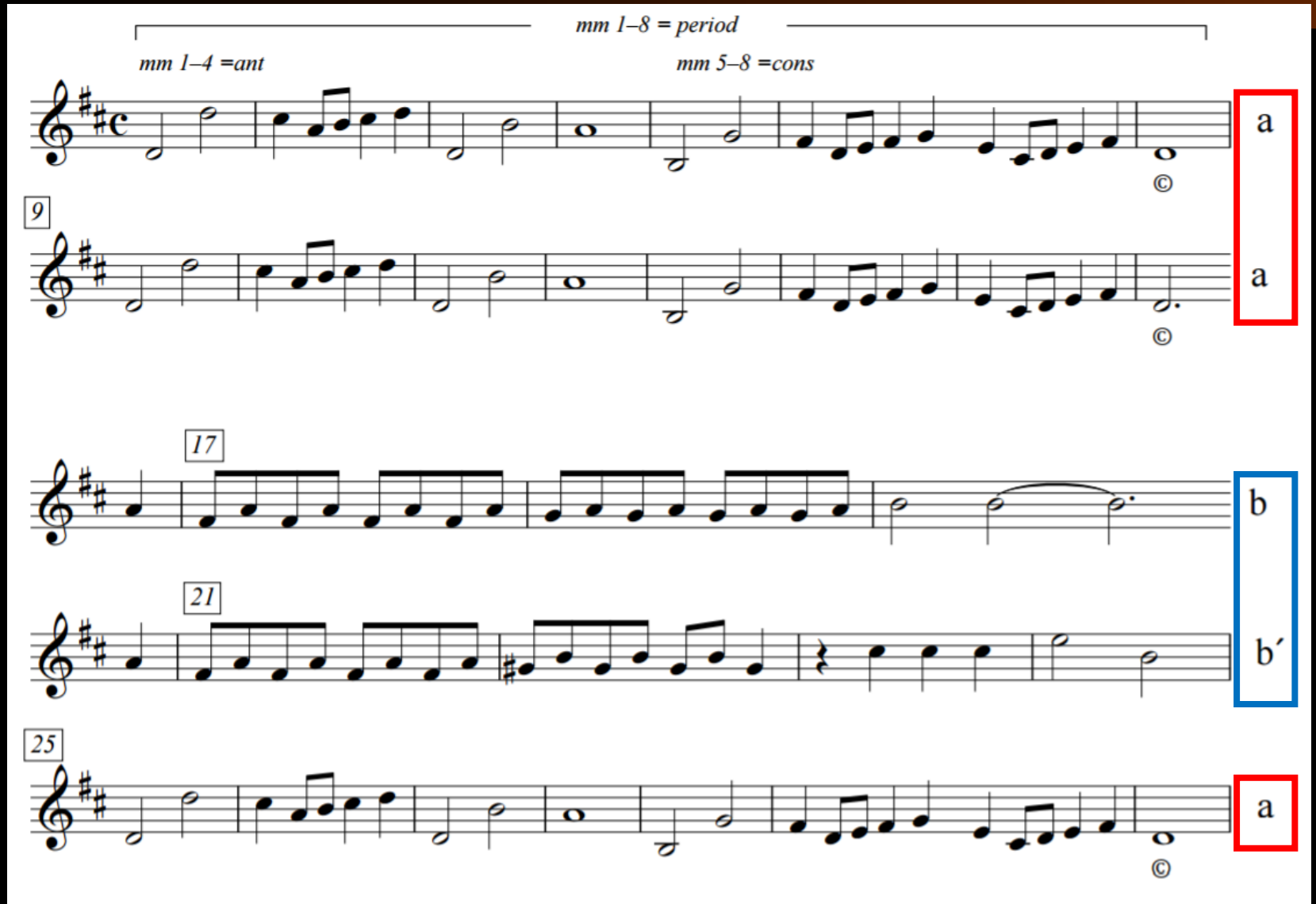
Musical Terminology



Musical Terminology

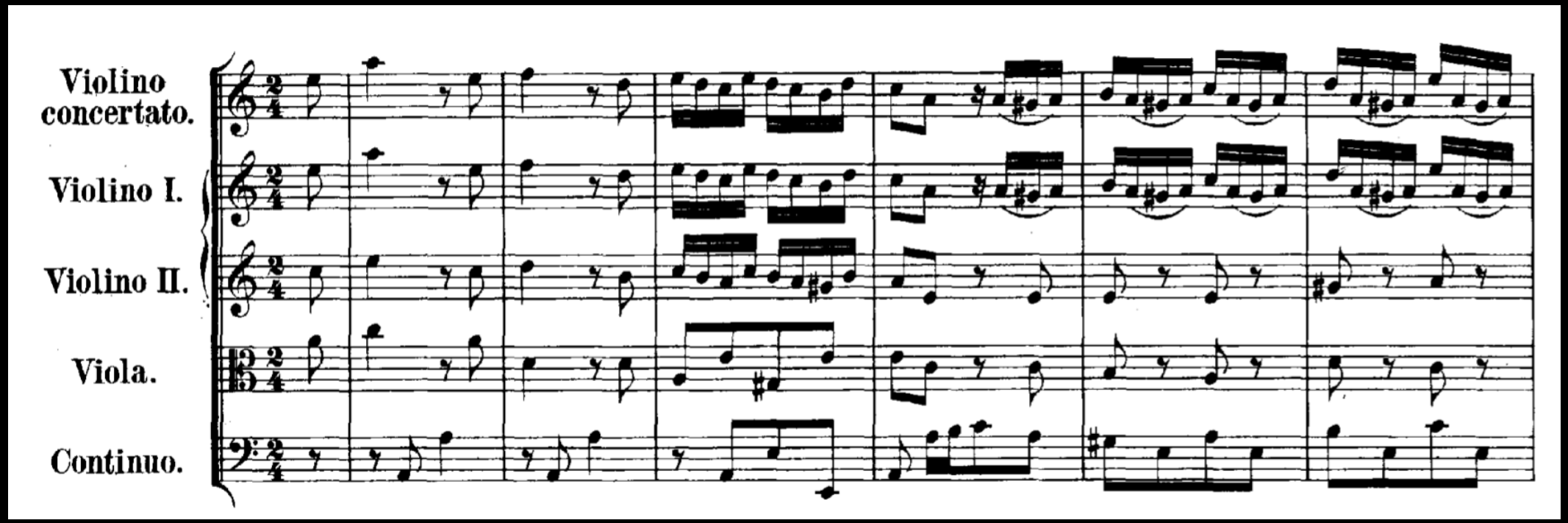


Musical Form



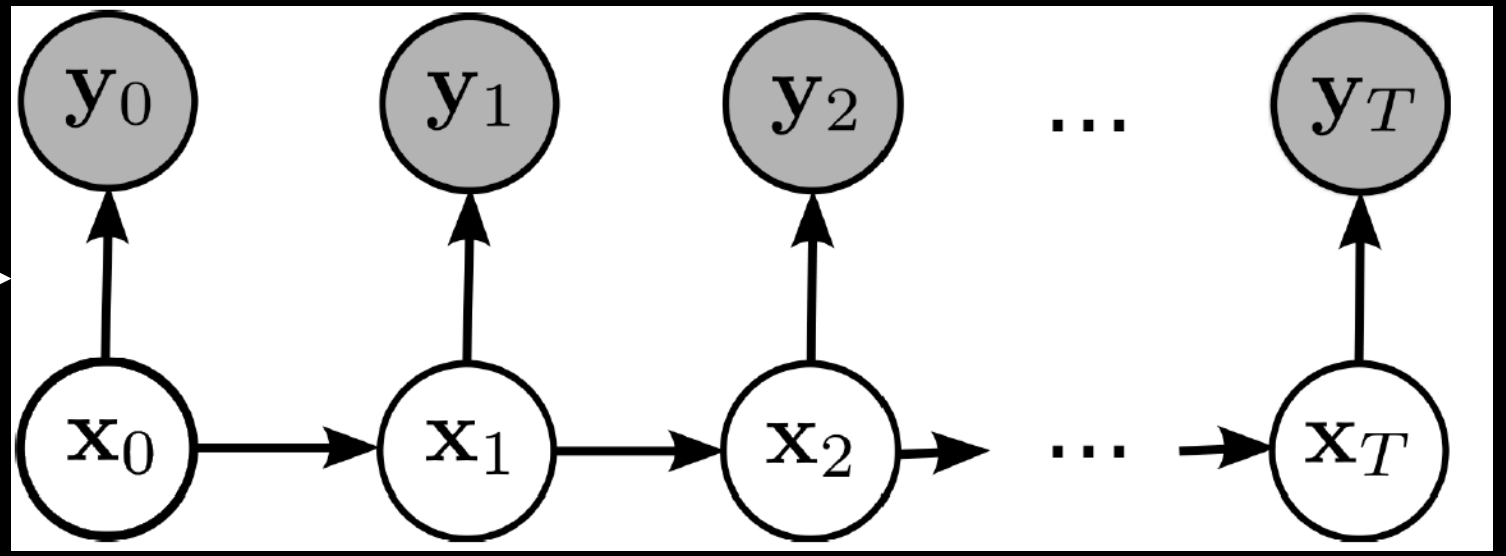
Data on Bach Music

- Analysis on Bach's works for violin
  - 2 Violin Concertos
  - 6 Violin Sonatas and Partitas

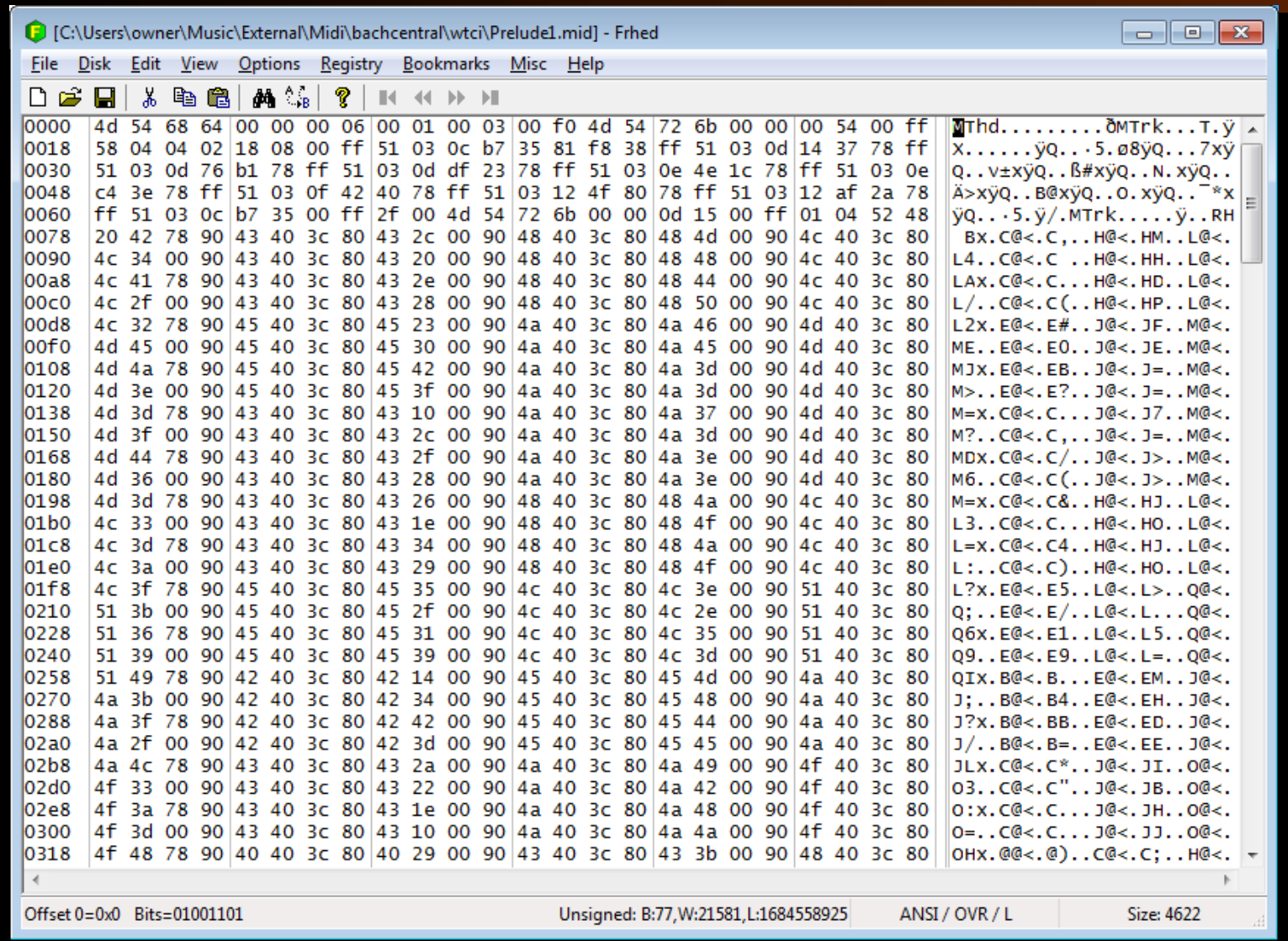


Methods

Musical Instrument Digital Interface



MIDIS

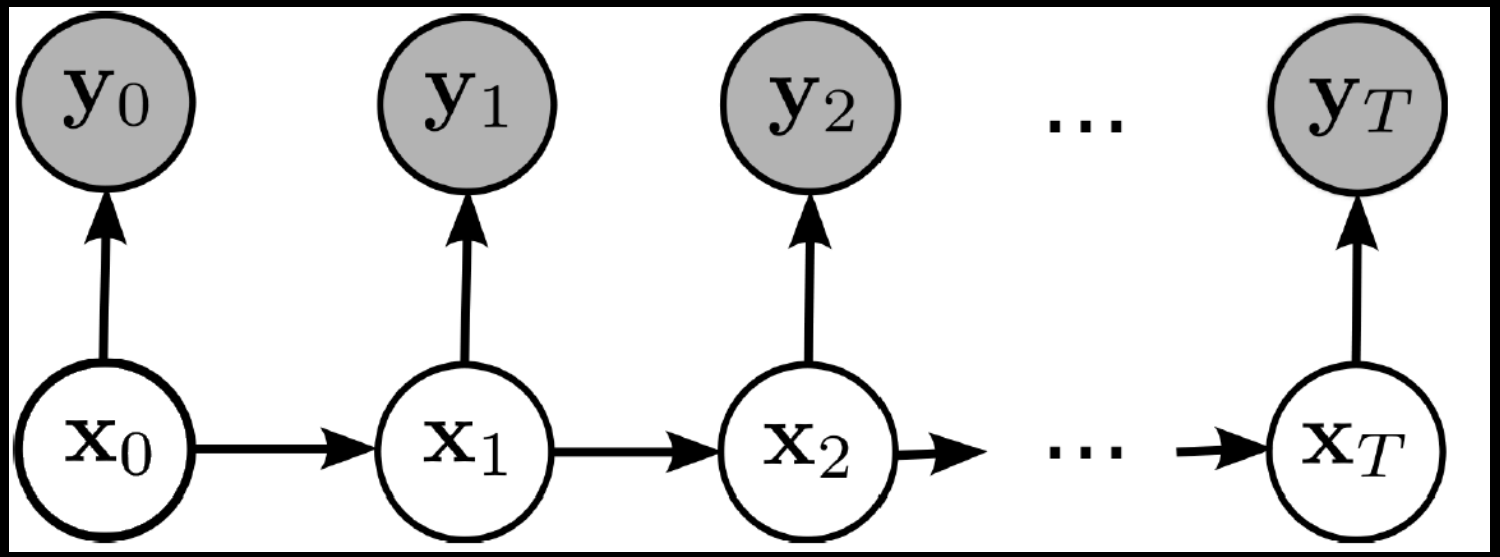

[C:\Users\owner\Music\External\Midi\bachcentral\wtci\Prelude1.mid] - Frhed
File Disk Edit View Options Registry Bookmarks Misc Help
0000 4d 54 68 64 00 00 00 06 00 01 00 03 00 f0 4d 54 72 6b 00 00 00 54 00 ff MThd.....ðMTrk...T.ÿ
0018 58 04 04 02 18 08 00 ff 51 03 0c b7 35 81 f8 38 ff 51 03 0d 14 37 78 ff X.....ÿQ..·5.ø8ÿQ...7xÿ
0030 51 03 0d 76 b1 78 ff 51 03 0d df 23 78 ff 51 03 0e 4e 1c 78 ff 51 03 0e Q..v±xÿQ..ß#xÿQ..N.xÿQ..
0048 c4 3e 78 ff 51 03 0f 42 40 78 ff 51 03 12 4f 80 78 ff 51 03 12 af 2a 78 Ä>xÿQ..B@xÿQ..O.xÿQ..¯*x
0060 ff 51 03 0c b7 35 00 ff 2f 00 4d 54 72 6b 00 00 0d 15 00 ff 01 04 52 48 ÿQ..·5.ÿ/.MTrk.....ÿ..RH
0078 20 42 78 90 43 40 3c 80 43 2c 00 90 48 40 3c 80 48 4d 00 90 4c 40 3c 80 Bx.C@<.C,..H@<.HM..L@<.
0090 4c 34 00 90 43 40 3c 80 43 20 00 90 48 40 3c 80 48 48 00 90 4c 40 3c 80 L4..C@<.C ..H@<.HH..L@<.
00a8 4c 41 78 90 43 40 3c 80 43 2e 00 90 48 40 3c 80 48 44 00 90 4c 40 3c 80 LAx.C@<.C...H@<.HD..L@<.
00c0 4c 2f 00 90 43 40 3c 80 43 28 00 90 48 40 3c 80 48 50 00 90 4c 40 3c 80 L/..C@<.C(..H@<.HP..L@<.
00d8 4c 32 78 90 45 40 3c 80 45 23 00 90 4a 40 3c 80 4a 46 00 90 4d 40 3c 80 L2x.E@<.E#..J@<.JF..M@<.
00f0 4d 45 00 90 45 40 3c 80 45 30 00 90 4a 40 3c 80 4a 45 00 90 4d 40 3c 80 ME..E@<.E0..J@<.JE..M@<.
0108 4d 4a 78 90 45 40 3c 80 45 42 00 90 4a 40 3c 80 4a 3d 00 90 4d 40 3c 80 MJx.E@<.EB..J@<.J=..M@<.
0120 4d 3e 00 90 45 40 3c 80 45 3f 00 90 4a 40 3c 80 4a 3d 00 90 4d 40 3c 80 M>..E@<.E?..J@<.J=..M@<.
0138 4d 3d 78 90 43 40 3c 80 43 10 00 90 4a 40 3c 80 4a 37 00 90 4d 40 3c 80 M=x.C@<.C...J@<.J7..M@<.
0150 4d 3f 00 90 43 40 3c 80 43 2c 00 90 4a 40 3c 80 4a 3d 00 90 4d 40 3c 80 M?..C@<.C,..J@<.J=..M@<.
0168 4d 44 78 90 43 40 3c 80 43 2f 00 90 4a 40 3c 80 4a 3e 00 90 4d 40 3c 80 MDx.C@<.C/..J@<.J>..M@<.
0180 4d 36 00 90 43 40 3c 80 43 28 00 90 4a 40 3c 80 4a 3e 00 90 4d 40 3c 80 M6..C@<.C(..J@<.J>..M@<.
0198 4d 3d 78 90 43 40 3c 80 43 26 00 90 48 40 3c 80 48 4a 00 90 4c 40 3c 80 M=x.C@<.C&..H@<.HJ..L@<.
01b0 4c 33 00 90 43 40 3c 80 43 1e 00 90 48 40 3c 80 48 4f 00 90 4c 40 3c 80 L3..C@<.C...H@<.HO..L@<.
01c8 4c 3d 78 90 43 40 3c 80 43 34 00 90 48 40 3c 80 48 4a 00 90 4c 40 3c 80 L=x.C@<.C4..H@<.HJ..L@<.
01e0 4c 3a 00 90 43 40 3c 80 43 29 00 90 48 40 3c 80 48 4f 00 90 4c 40 3c 80 L:..C@<.C)..H@<.HO..L@<.
01f8 4c 3f 78 90 45 40 3c 80 45 35 00 90 4c 40 3c 80 4c 3e 00 90 51 40 3c 80 L?x.E@<.E5..L@<.L>..Q@<.
0210 51 3b 00 90 45 40 3c 80 45 2f 00 90 4c 40 3c 80 4c 2e 00 90 51 40 3c 80 Q;..E@<.E/..L@<.L...Q@<.
0228 51 36 78 90 45 40 3c 80 45 31 00 90 4c 40 3c 80 4c 35 00 90 51 40 3c 80 Q6x.E@<.E1..L@<.L5..Q@<.
0240 51 39 00 90 45 40 3c 80 45 39 00 90 4c 40 3c 80 4c 3d 00 90 51 40 3c 80 Q9..E@<.E9..L@<.L=..Q@<.
0258 51 49 78 90 42 40 3c 80 42 14 00 90 45 40 3c 80 45 4d 00 90 4a 40 3c 80 QIx.B@<.B...E@<.EM..J@<.
0270 4a 3b 00 90 42 40 3c 80 42 34 00 90 45 40 3c 80 45 48 00 90 4a 40 3c 80 J;..B@<.B4..E@<.EH..J@<.
0288 4a 3f 78 90 42 40 3c 80 42 42 00 90 45 40 3c 80 45 44 00 90 4a 40 3c 80 J?x.B@<.BB..E@<.ED..J@<.
02a0 4a 2f 00 90 42 40 3c 80 42 3d 00 90 45 40 3c 80 45 45 00 90 4a 40 3c 80 J/..B@<.B=..E@<.EE..J@<.
02b8 4a 4c 78 90 43 40 3c 80 43 2a 00 90 4a 40 3c 80 4a 49 00 90 4f 40 3c 80 JLx.C@<.C*..J@<.JI..O@<.
02d0 4f 33 00 90 43 40 3c 80 43 22 00 90 4a 40 3c 80 4a 42 00 90 4f 40 3c 80 O3..C@<.C"..J@<.JB..O@<.
02e8 4f 3a 78 90 43 40 3c 80 43 1e 00 90 4a 40 3c 80 4a 48 00 90 4f 40 3c 80 O:x.C@<.C...J@<.JH..O@<.
0300 4f 3d 00 90 43 40 3c 80 43 10 00 90 4a 40 3c 80 4a 4a 00 90 4f 40 3c 80 O=..C@<.C...J@<.JJ..O@<.
0318 4f 48 78 90 40 40 3c 80 40 29 00 90 43 40 3c 80 43 3b 00 90 48 40 3c 80 OHx.@@<.@)..C@<.C;..H@<.
Offset 0=0x0 Bits=01001101
Unsigned: B:77,W:21581,L:1684558925
ANSI / OVR / L
Size: 4622

MIDIS

- Python Library Mido
  - MIDI Objects for Python
- Chose to ignore note durations

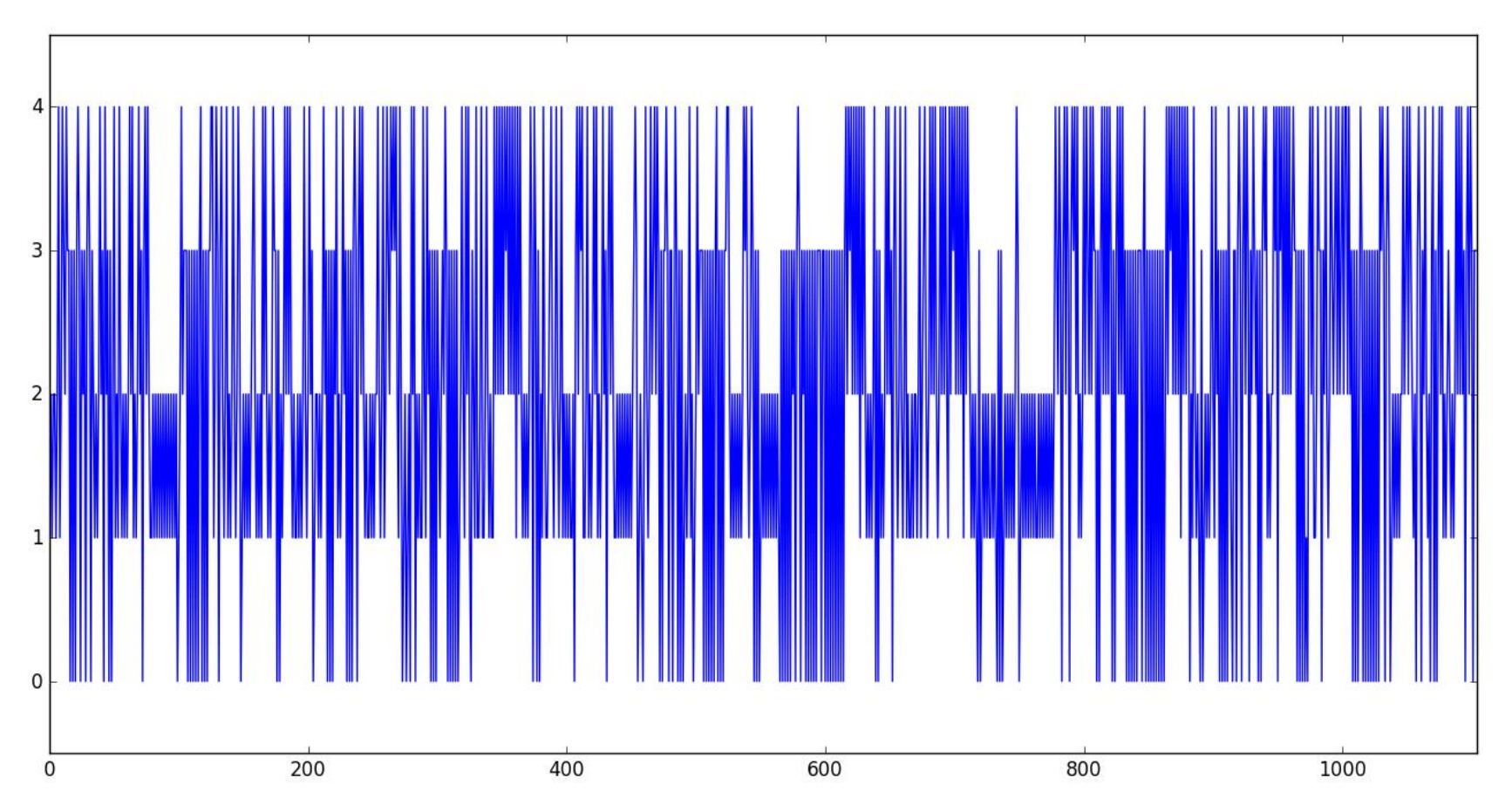
```
Track 0: untitled
<meta message track_name name='untitled' time=0>
<meta message smpte_offset frame_rate=25 hours=32 minutes=0 seconds=3 frames=0 sub_frames=0 time=0>
<meta message time_signature numerator=2 denominator=4 clocks_per_click=24 notated_32nd_notes_per_beat=8 time=0>
<meta message key_signature key='C' time=0>
<meta message set_tempo tempo=645161 time=0>
<meta message end_of_track time=0>
Track 1: Solo Violin
<meta message midi_port port=0 time=0>
<meta message track_name name='Solo Violin' time=0>
program_change channel=0 program=40 time=0
control_change channel=0 control=7 value=115 time=0
control_change channel=0 control=10 value=64 time=0
note_on channel=0 note=76 velocity=100 time=576
note_on channel=0 note=76 velocity=0 time=192
note_on channel=0 note=81 velocity=100 time=0
note_on channel=0 note=81 velocity=0 time=384
note_on channel=0 note=76 velocity=100 time=192
note_on channel=0 note=76 velocity=0 time=192
note_on channel=0 note=77 velocity=100 time=0
note_on channel=0 note=77 velocity=0 time=384
note_on channel=0 note=74 velocity=100 time=192
note_on channel=0 note=74 velocity=0 time=192
note_on channel=0 note=76 velocity=100 time=0
note_on channel=0 note=76 velocity=0 time=96
note_on channel=0 note=74 velocity=100 time=0
note_on channel=0 note=74 velocity=0 time=96
note_on channel=0 note=72 velocity=100 time=0
note_on channel=0 note=72 velocity=0 time=96
note_on channel=0 note=76 velocity=100 time=0
note_on channel=0 note=76 velocity=0 time=96
note_on channel=0 note=74 velocity=100 time=0
note_on channel=0 note=74 velocity=0 time=96
note_on channel=0 note=72 velocity=100 time=0
```

Multinomial HMM



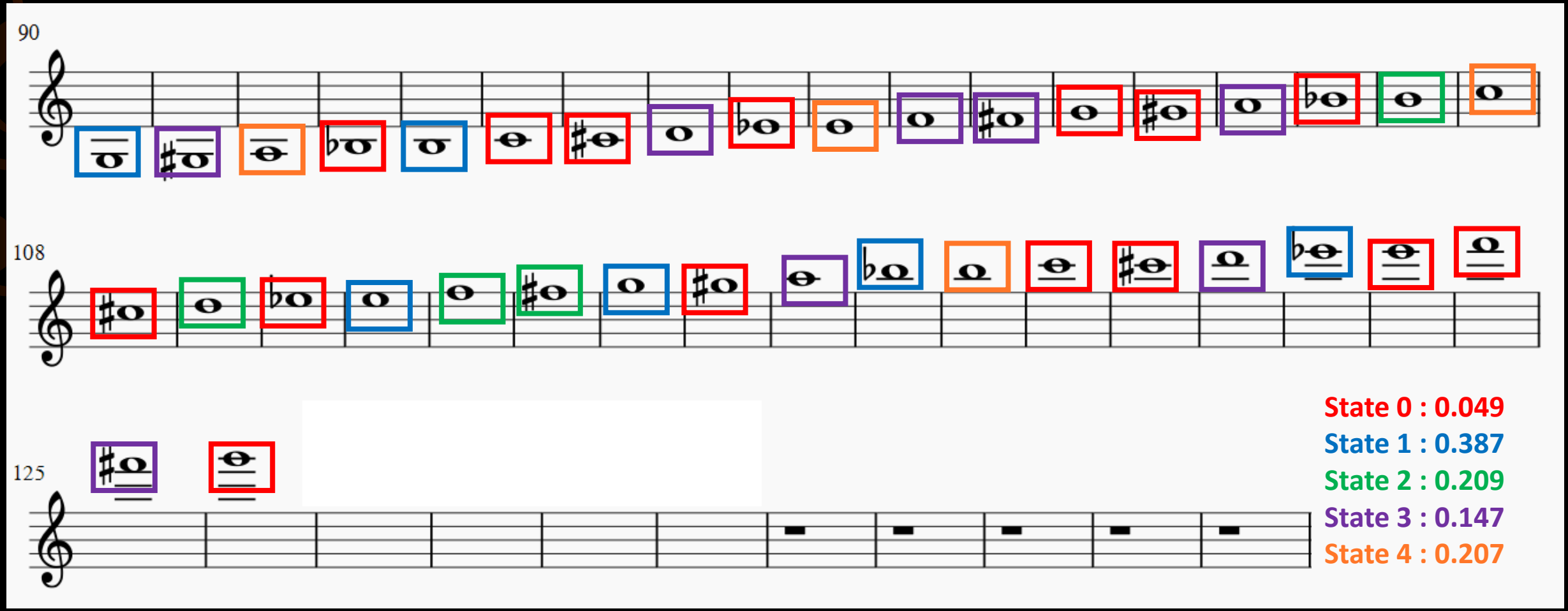
- Unsupervised Approach
- Assumes discrete time steps
- Uses Viterbi
- HMMLearn Package

Results

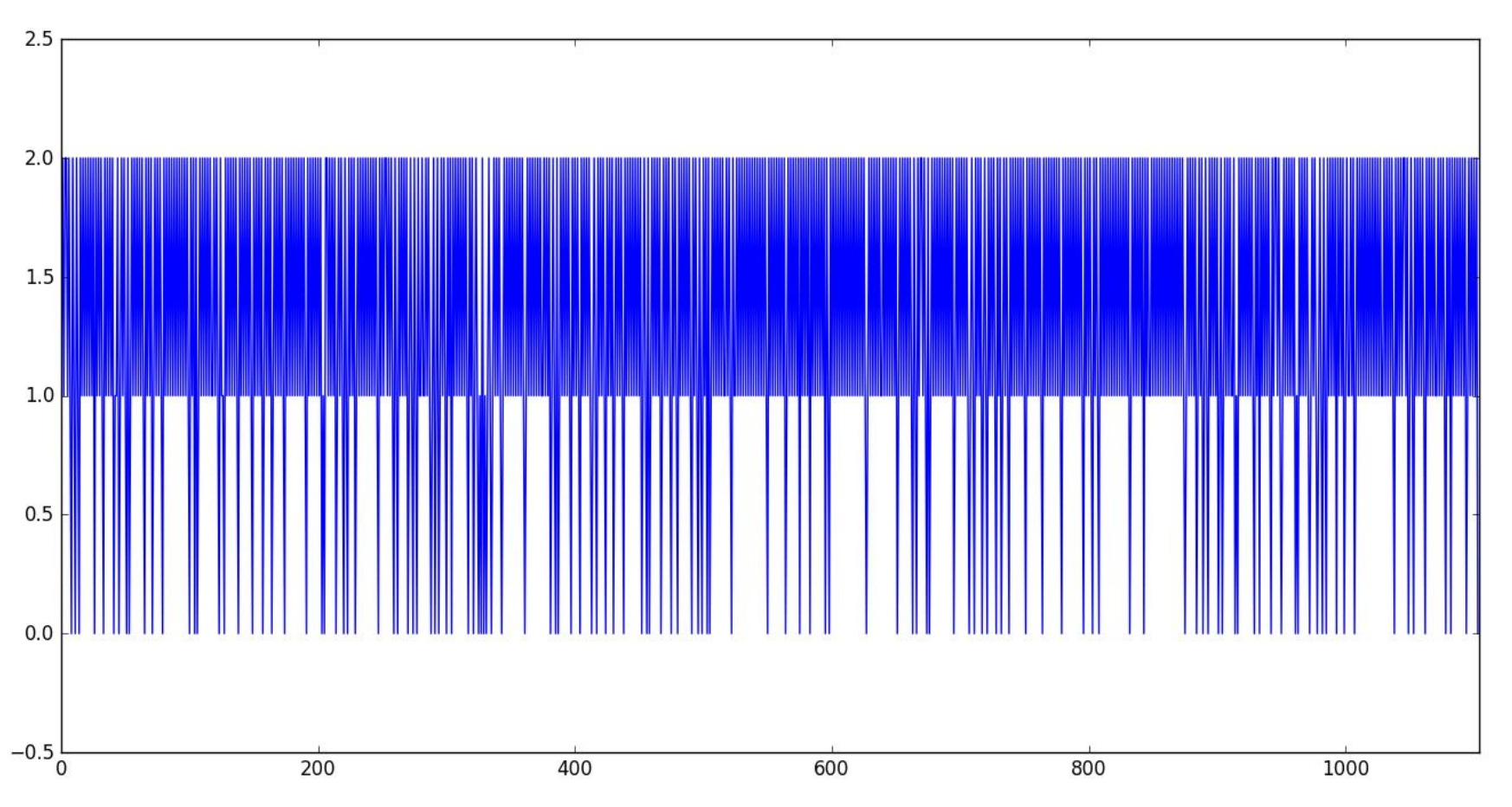


- Trained with 5 hidden layers
  - The 1st movement of the Bach A minor Concerto has about 5 repetitive motifs
- The HMM calculates states based on the previous note
- Can’t discern much

Results


90
108
125
State 0 : 0.049
State 1 : 0.387
State 2 : 0.209
State 3 : 0.147
State 4 : 0.207

Results



- Run HMM in the hidden states from prior
- Trained on 3 hidden layers

State 0 : [State 1]
State 1 : [State 0 , State 4]
State 2 : [State 2, State 3]

Future Work

- Parse data to be grouped by measures
- Run a N-gram model, which predicts based on the probability of multiple previous states
- Try other composers other than Bach

Questions?

- http://ieeexplore.ieee.org/document/4607732/?arnumber=4607732

Another NYC Data Analysis

but with **Citi Bike**

Jackie Byun CSC390

Motivation

- Increasing popularity of public bike sharing systems
- First personal experience with bike share was during summer internship in Chicago
- The entire process from membership, rental, check out & return time, etc. has now become automatic
- But unlike taxi (or Uber) data, Citi Bike includes demographic information about its riders

Data

Millions of data points for each month between 2013-2016

Chose 09/2016

tripduration	starttime	stoptime	start station	start station	start station	start station	end station i	end station n	end station	end station	bikeid	usertype	birth year	gender
975	9/1/16 0:00	9/1/16 0:16	312	Allen St & Sta	40.722055	-73.989111	313	Washington	40.6961023	-73.96751	22609	Subscriber	1985	1
1220	9/1/16 0:00	9/1/16 0:20	316	Fulton St & W	40.7095596	-74.006536	239	Willoughby S	40.6919657	-73.981302	16966	Subscriber	1977	2
308	9/1/16 0:00	9/1/16 0:05	479	9 Ave & W 45	40.7601925	-73.991255	448	W 37 St & 10	40.7566036	-73.997901	25601	Subscriber	1983	1
250	9/1/16 0:00	9/1/16 0:04	297	E 15 St & 3 A	40.734232	-73.986923	487	E 20 St & FDR	40.7331426	-73.975739	22094	Subscriber	1953	1
439	9/1/16 0:00	9/1/16 0:07	494	W 26 St & 8 A	40.7473483	-73.997236	533	Broadway &	40.7529964	-73.987216	16319	Subscriber	1985	1
730	9/1/16 0:00	9/1/16 0:12	491	E 24 St & Par	40.7409637	-73.986022	477	W 41 St & 8 A	40.7564055	-73.990026	23730	Subscriber	1986	1
188	9/1/16 0:00	9/1/16 0:03	531	Forsyth St &	40.718939	-73.992663	361	Allen St & He	40.7160587	-73.991908	22832	Subscriber	1988	2
776	9/1/16 0:00	9/1/16 0:13	519	Pershing Squ	40.751873	-73.977706	237	E 11 St & 2 A	40.7304731	-73.986724	14719	Subscriber	1986	1

- m = 1648856
- p = 5

Data

Five features: trip duration, start latitude, start longitude, stop latitude, stop longitude

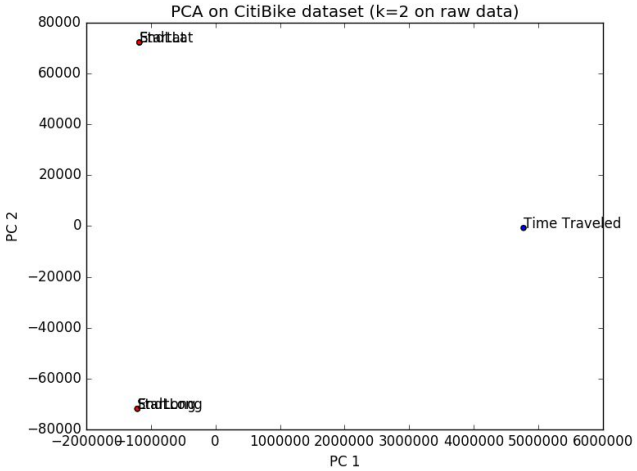
Looking for clustering patterns ➔ Unsupervised

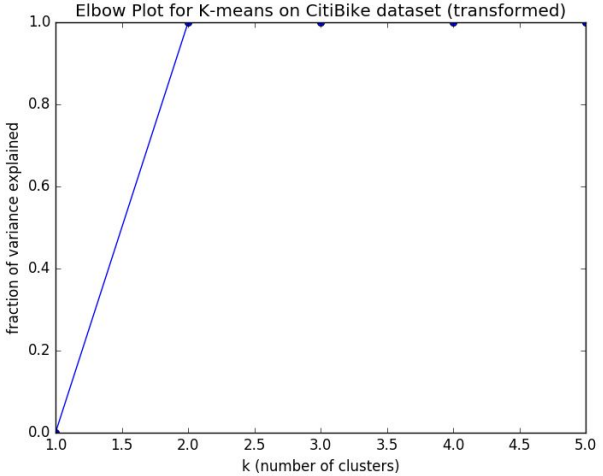
Use gender feature as a label to evaluate model afterwards

Methods

PCA ➔ results not meaningful in terms of visualization

Elbow plot ➔ shows k = 2





Methods

Matplotlib Basemap to map station data by latitude and longitude

```
from mpl_toolkits.basemap import Basemap
startlats = X[1]
startlongs = X[2]
m = Basemap(llcrnrlon=min(startlongs),llcrnrlat=min(startlats),urcrnrlon=max(startlongs),urcrnrlat=max(startlats),
            lat_ts=20,resolution='c',projection='merc',lon_0=startlongs[0],lat_0=startlats[0])
```

llcrnrlat,llcrnrlon,urcrnrlat,urcrnrlon

➜ are the lat/lon values of the lower left and upper right corners of the map

lat_ts ➜ the latitude of true scale.

resolution = 'c' ➜ means use crude resolution coastlines

Expected Outcomes and Challenges

Map visualization of the Citi Bike station locations

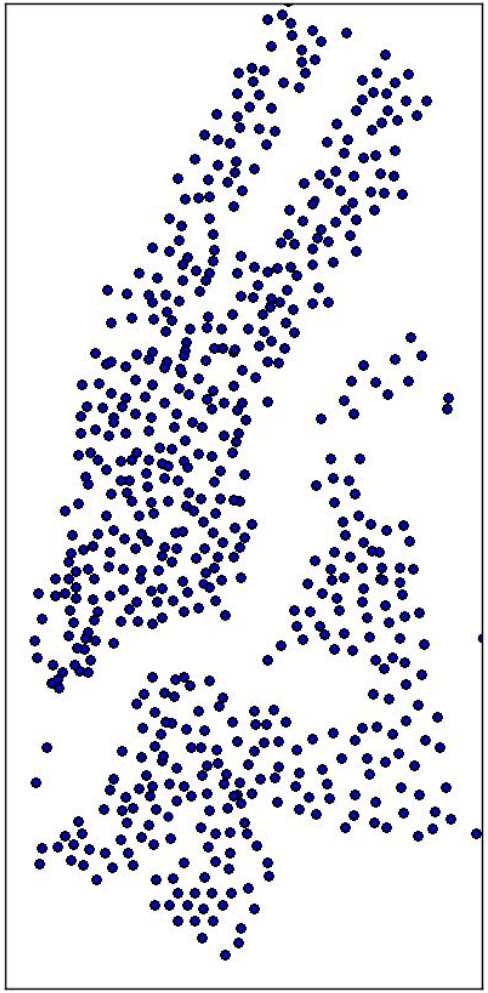
K-means clustering of data

Better understanding of rider demographics and use by areas in the city

Challenges: Preprocessing a very large dataset, fixed pick up and drop off locations obscure data point individuality and makes it difficult to find a pattern

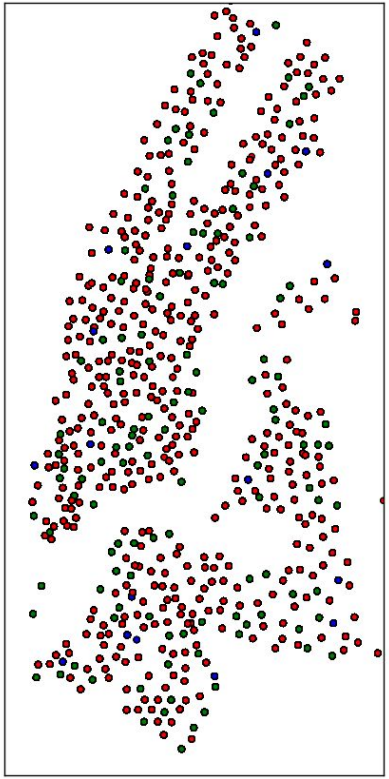
Expected Outcomes

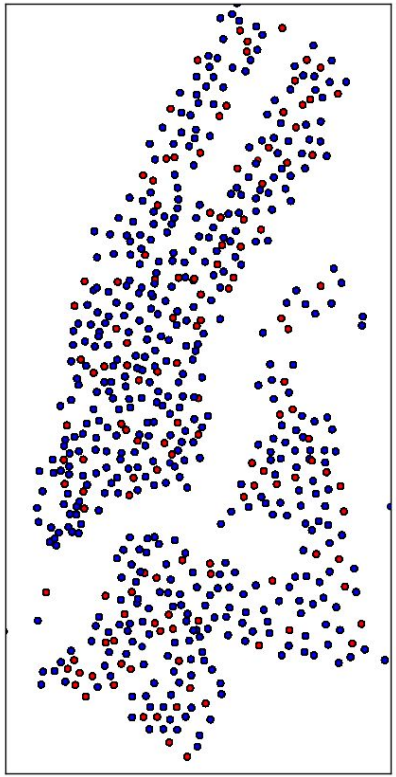
Map visualization of the Citi Bike station locations



Expected Outcomes

Colored by gender





Colored by k=2

Future Directions

Color based on the gender majority seen at each station

Interesting to find out more about distinct commuting patterns: what are the most popular roads?

Analysis with specific times: rush hour vs accidents

What neighborhoods have the highest and lowest ratios of Citi Bike rides compared to taxi or Uber trips? And are there any commutes where it’s faster to take a Citi Bike than a taxi/Uber during rush hour traffic?

Underestimate how much easier it is to uniquely identify people based on the additional demographic data that is made available to the public

Thank You and Questions?

K means and PCA on individual household electricity power consumption data

Presentation by Karen Stefany Diaz

Motivation / Why is it important?

- I wanted to create a visual representation of a data set for this final project ☺
- Data set used applied to a product used in our daily lives
  - Data records household consumption of power over 4 years
- Can assist in seeing trends on energy usage and reduce the amount of energy we use
- Knowing when peak times can put a lot of strain on system
- Interest now on how to distribute systems (power grid) efficiently
- Can be useful in electricity load forecasting
  - Important aspect of power systems planning and operation
  - Forecasting permits using energy storage systems to decrease cost of energy for consumers

Supervised vs Unsupervised

- Unsupervised methods in project
  - K means + PCA
- No true labels were provided with Data Set
- Only information provided were the measurements and the date +time of each test
  - date +time more of a special feature to look at afterward, not a label to be predicted

Data

- Data provided from UCI Machine Learning Repository
- Measurements of electric power consumption in one household with a one-minute sampling rate over a period of almost 4 years.
- Different electrical quantities and some sub-metering values are available.

Data – Data Set Information

- This archive contains 2,075,259 measurements gathered between December 2006 and November 2010 (47 months).
- Represents the active energy consumed every minute (in watt hour) in the household by electrical equipment measured in sub-meterings 1, 2 and 3.
- The dataset contains some missing values in the measurements. All calendar timestamps are present in the dataset but for some timestamps, the measurement values are missing:
- A missing value is represented by the absence of value between two consecutive semi-colon attribute separators.

Data – Attribute Information

```
16/12/2006;17:24:00;4.216;0.418;234.840;18.400;0.000;1.000;17.000
16/12/2006;17:25:00;5.360;0.436;233.630;23.000;0.000;1.000;16.000
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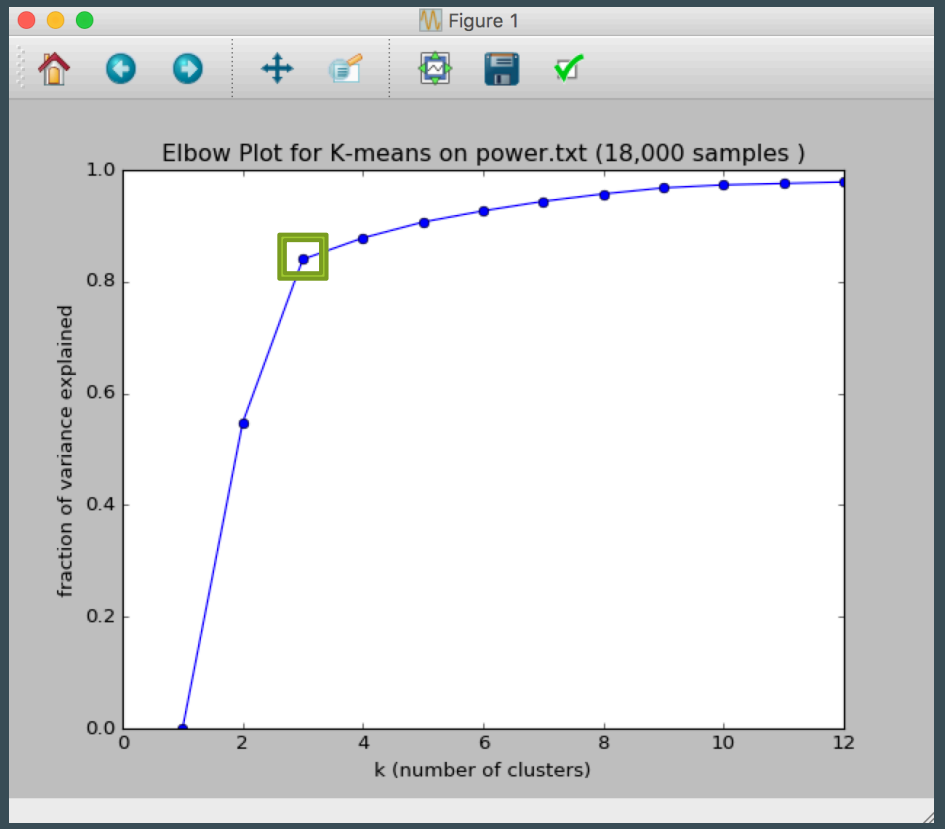
Methods

- Pre-processing data
  - For K Means and PCA had to ignore certain features in order for them to work
    - Ignored 1st and 2nd features of the data set
    - Date and time
  - As mentioned earlier, some dates contained missing values for the sub measurements.
    - If there was data missing, was replaced by '?'
    - Need to remove the row altogether if a '?' is present
- K-means
- PCA

Results



From Elbow Plot, k chosen was 3

Results

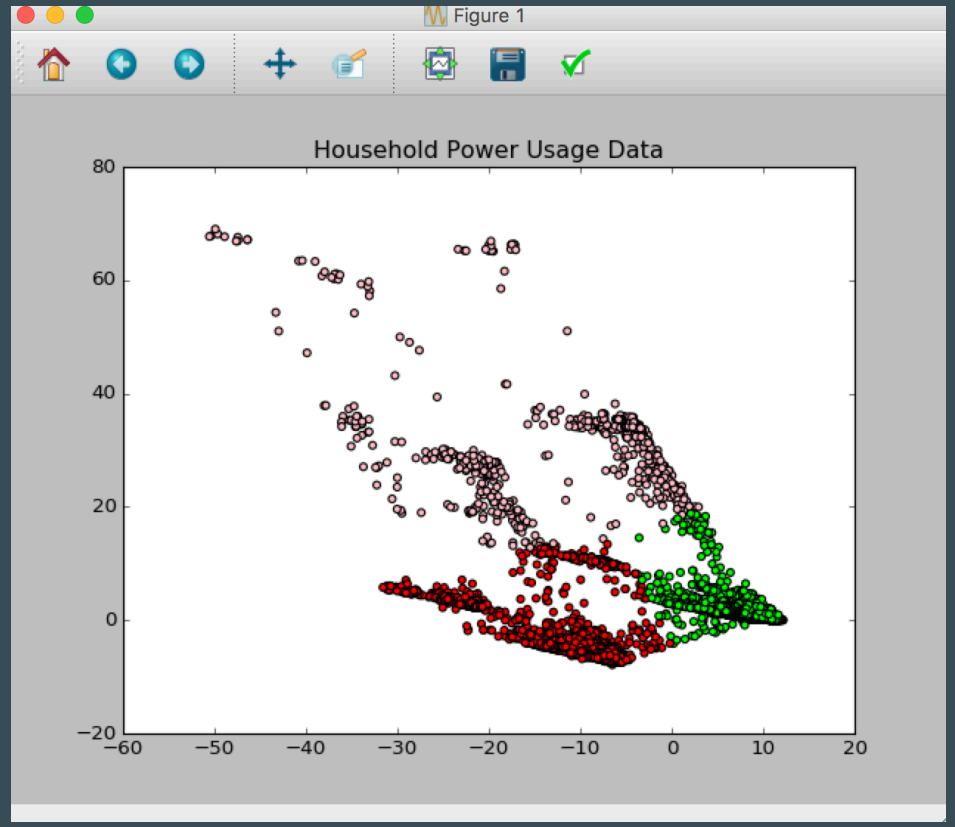


Figure 1
Household Power Usage Data
80
60
40
20
0
−20
−60
−50
−40
−30
−20
−10
0
10
20

Future work

- I plan to interpret the data in terms of day vs night
- Using class markers to plot data
- Want to divide up data into months
- Finding peak times in energy consumption

Thank you !

- comments / questions / suggestions?