MIDI
MUSIC GENERATOR

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OUTLINE

Database Overview

Data Preprocessing

Math of Evaluation

Evaluation

Database Overview

Data: http://www.piano-midi.de/midi_files.htm

In the midi file, there contain three important element note[24, 122], velocity[0, 128), time.

Data Preprocessing

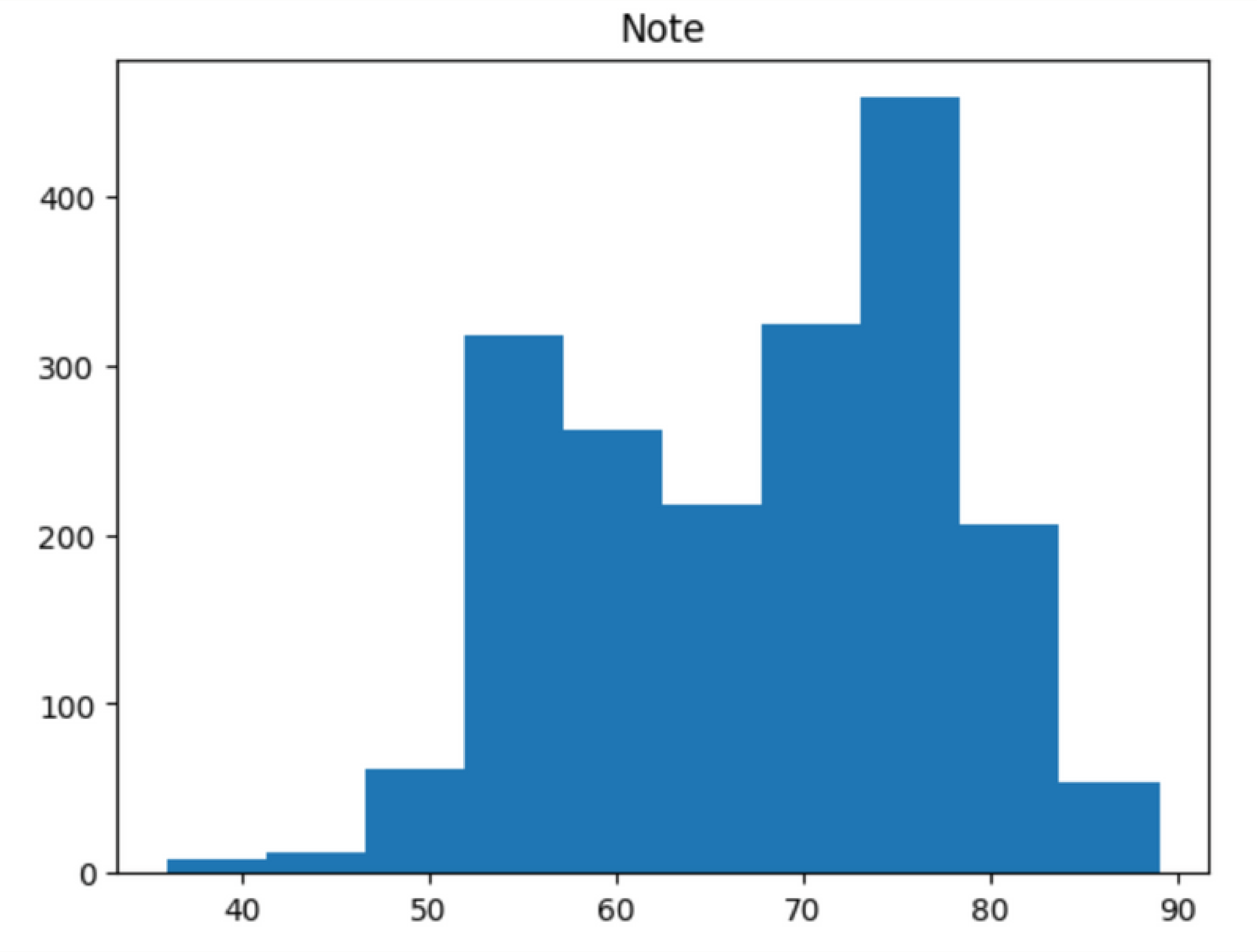
Reading the File

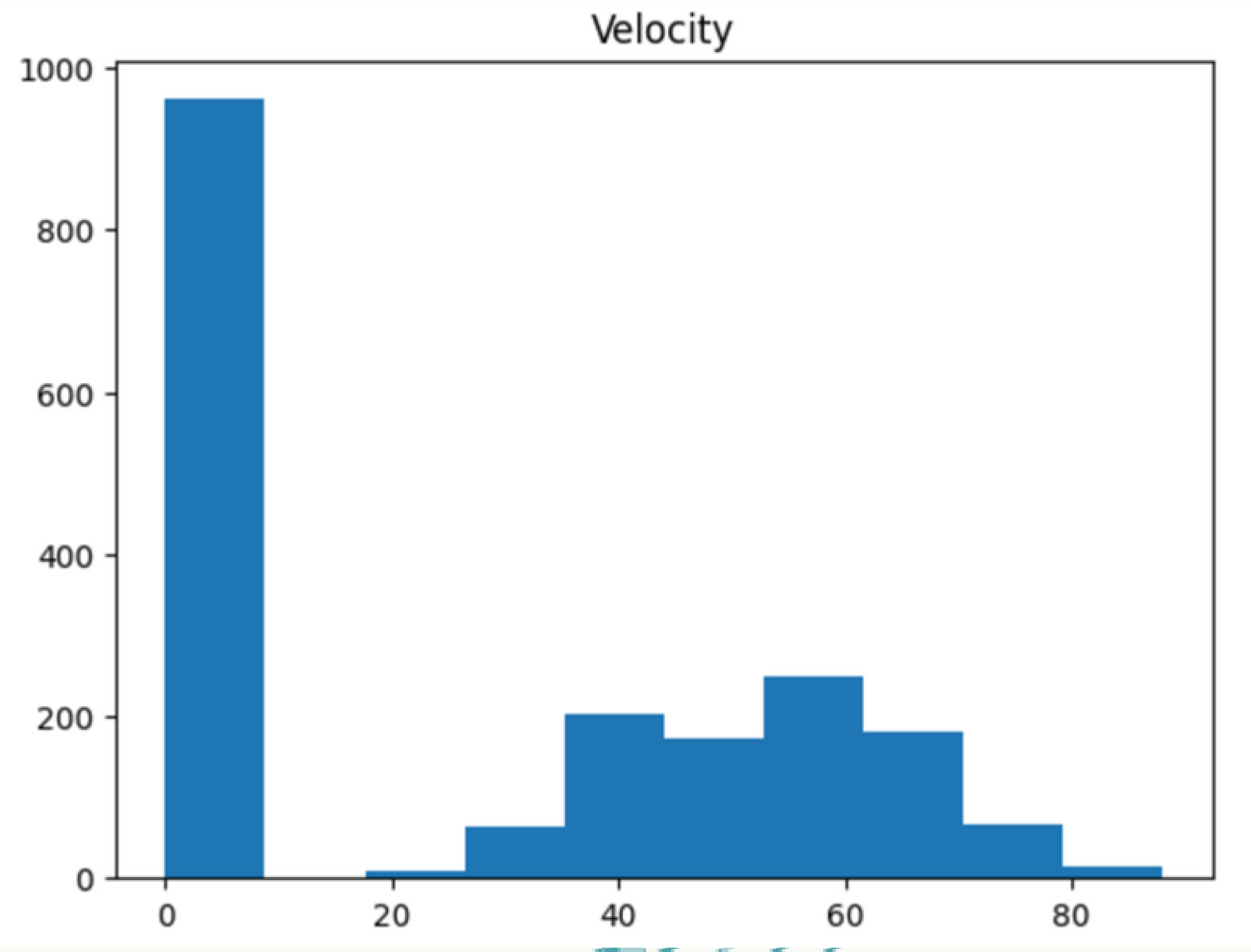
```
mid = MidiFile('./Sonata No. 16 C major  Rondo Allegretto.mid')

notes = []
time = float(0)
prev = float(0)

original = []

for msg in mid:
    time += msg.time

    if not msg.is_meta:
        if msg.channel == 0:
            if msg.type == 'note_on':
                # note[0] save pitch, note[1] save velocity, note[2] save time.
                note = msg.bytes()
                note = note[1:3]
                note.append(time - prev)
                prev = time
                notes.append(note)
                original.append([i for i in note])
```

Reading the File

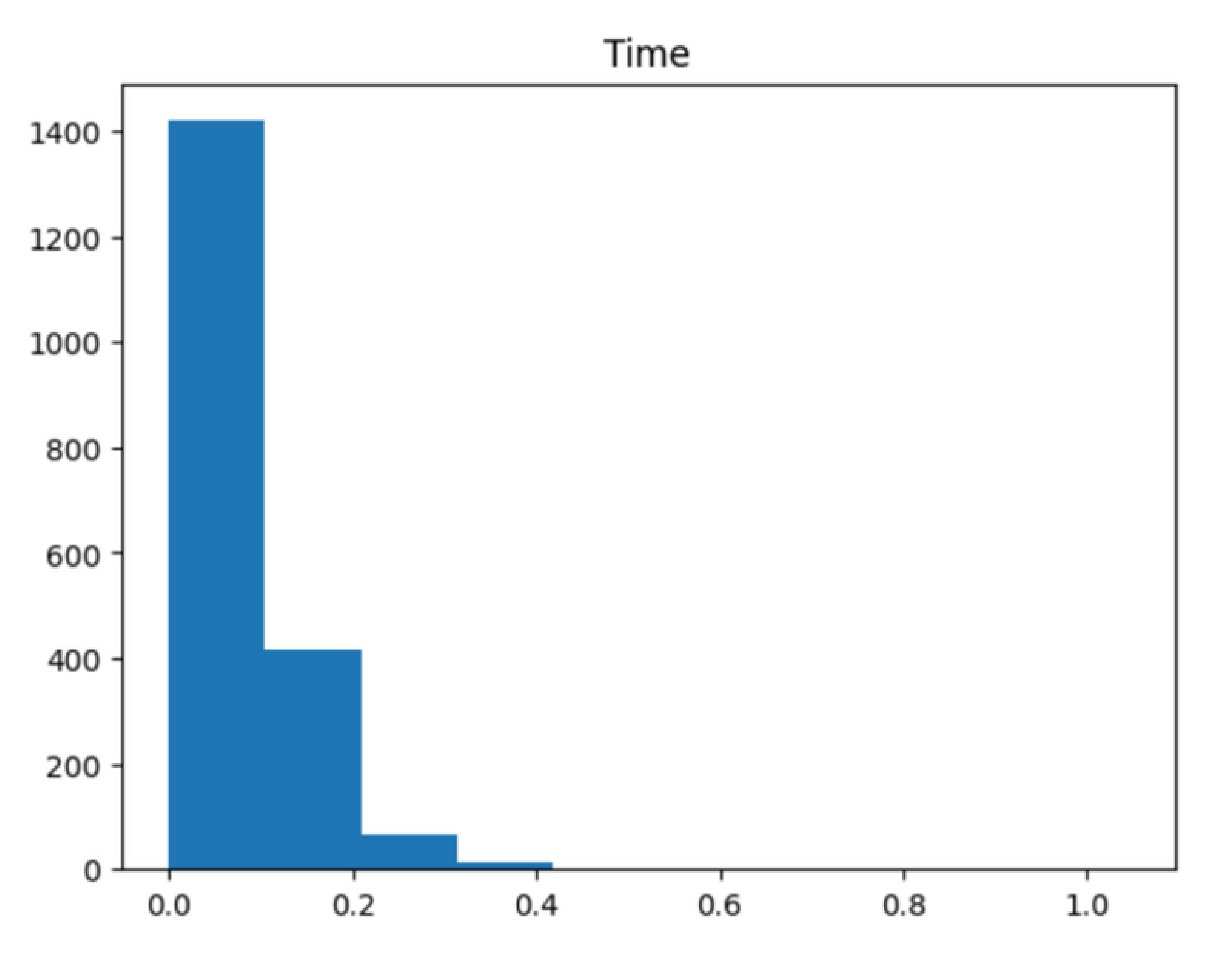
```
plt.figure()
plt.hist([i[0] for i in notes])
plt.title('Note')
plt.figure()
plt.hist([i[1] for i in notes])
plt.title('Velocity')
plt.figure()
plt.hist([i[2] for i in notes])
plt.title('Time')
```

Reading the File





Reading the File



Data Preprocessing

```
intervals = 10
values = np.array([i[2] for i in notes])
max_t = np.amax(values)
min_t = np.amin(values[values > 0])
interval = 1.0 * (max_t - min_t) / intervals

dataset = []
for note in notes:
    slot = np.zeros(229)

    # because note >= 24 and note <= 112, we first minus 24 to note.
    note[0] -= 24
    ind1 = note[0]
    # velocity >= 0 && velocity < 128
    ind2 = note[1]
    ind3 = int((note[2] - min_t) / interval + 1) if note[2] > 0 else 0
    slot[ind1] = 1
    slot[89 + ind2] = 1
    slot[89 + 128 + ind3] = 1
    dataset.append(slot)
```

Data Preprocessing

```
X = []
Y = []

n_prev = 10

for i in range(len(dataset) - n_prev):
    x = dataset[i:i+n_prev]
    y = notes[i+n_prev]
    ind3 = int((y[2] - min_t) / interval + 1) if y[2] > 0 else 0
    y[2] = ind3

    X.append(x)
    Y.append(y)

seed = dataset[0:n_prev]

idx = np.random.permutation(range(len(X)))
X = [X[i] for i in idx]
Y = [Y[i] for i in idx]

validX = X[: len(X) // 10]
X = X[len(X) // 10 :]
validY = Y[: len(Y) // 10]
Y = Y[len(Y) // 10 :]
```

Data Preprocessing

```
batch_size = 16

train_ds = DataSet.TensorDataset(torch.FloatTensor(np.array(X, dtype = float)), torch.LongTensor(np.array(Y)))
train_loader = DataSet.DataLoader(train_ds, batch_size = batch_size, shuffle = True, num_workers=4)

valid_ds = DataSet.TensorDataset(torch.FloatTensor(np.array(validX, dtype = float)), torch.LongTensor(np.array(validY)))
valid_loader = DataSet.DataLoader(valid_ds, batch_size = batch_size, shuffle = True, num_workers=4)
```

Math Evaluation

Gradient Descent

$$\theta new = \theta old - \eta \cdot \nabla \theta L$$

- θ: model parameters
- L: gradient of the loss function
- η: learning rate
- $\nabla \theta L$: gradient of the loss function with respect to the model parameters

Backpropagation

$\partial L / \partial w$

- L: loss function
- w: a weight in the network

Is used to update the weights in the direction that minimizes the loss.

LOSS FUNCTION (CROSS ENTROPY)

$$L = -1/N * \sum \log(p_i)$$

- L: cross-entropy loss
- pi: the predicted probability of the correct class for the ith sample

It penalizes predictions that are confident but wrong.

MODEL

```
class LSTMNetwork(nn.Module):
    def __init__(self, input_size, hidden_size, out_size, n_layers=1):
        super(LSTMNetwork, self).__init__()
        self.n_layers = n_layers
        self.hidden_size = hidden_size
        self.out_size = out_size
        self.lstm = nn.LSTM(input_size, hidden_size, n_layers, batch_first = True)
        self.dropout = nn.Dropout(0.2)
        self.fc = nn.Linear(hidden_size, out_size)
        self.softmax = nn.LogSoftmax(dim = 1)

    def forward(self, input, hidden=None):
        hhh1 = hidden[0]
        output, hhh1 = self.lstm(input, hhh1)
        output = self.dropout(output)
        output = output[:, -1, ...]
        out = self.fc(output)

        x = self.softmax(out[:, :89])
        y = self.softmax(out[:, 89: 89 + 128])
        z = self.softmax(out[:, 89 + 128:])
        return (x,y,z)
```

MODEL

```
def initHidden(self, batch_size):
    out = []
    hidden1=torch.zeros(1, batch_size, self.hidden_size)
    cell1=torch.zeros(1, batch_size, self.hidden_size)
    out.append((hidden1, cell1))
    return out
```

Define criterion and rightness

```python
def criterion(outputs, target):
    x, y, z = outputs
    loss_f = nn.NLLLoss()
    loss1 = loss_f(x, target[:, 0])
    loss2 = loss_f(y, target[:, 1])
    loss3 = loss_f(z, target[:, 2])
    return loss1 + loss2 + loss3

def rightness(predictions, labels):
    pred = torch.max(predictions.data, 1)[1]
    rights = pred.eq(labels.data).sum()
    return rights, len(labels)
```

TRAIN

```
lstm = LSTMNetwork(229, 64, 229)
optimizer = optim.SGD(lstm.parameters(), lr=1e-1, momentum=0.9)
num_epochs = 100
train_losses = []
valid_losses = []
records = []
```

TRAIN

```
for epoch in range(num_epochs):
    train_loss = []
    for batch, data in enumerate(train_loader):
        lstm.train()
        init_hidden = lstm.initHidden(len(data[0]))
        optimizer.zero_grad()
        x, y = data[0].clone().detach().requires_grad_(True), data[1].clone().detach()
        outputs = lstm(x, init_hidden)
        loss = criterion(outputs, y)
        train_loss.append(loss.data.numpy())
        loss.backward()
        optimizer.step()
```

TRAIN

```
valid_loss = []
lstm.eval()
rights = []
for batch, data in enumerate(valid_loader):
    init_hidden = lstm.initHidden(len(data[0]))
    x, y = data[0].clone().detach().requires_grad_(True), data[1].clone().detach()
    outputs = lstm(x, init_hidden)
    loss = criterion(outputs, y)
    valid_loss.append(loss.data.numpy())
    right1 = rightness(outputs[0], y[:, 0])
    right2 = rightness(outputs[1], y[:, 1])
    right3 = rightness(outputs[2], y[:, 2])
    rights.append((right1[0] + right2[0] + right3[0]).numpy() * 1.0 / (right1[1] + right2[1] + right3[1]))
```

TRAIN

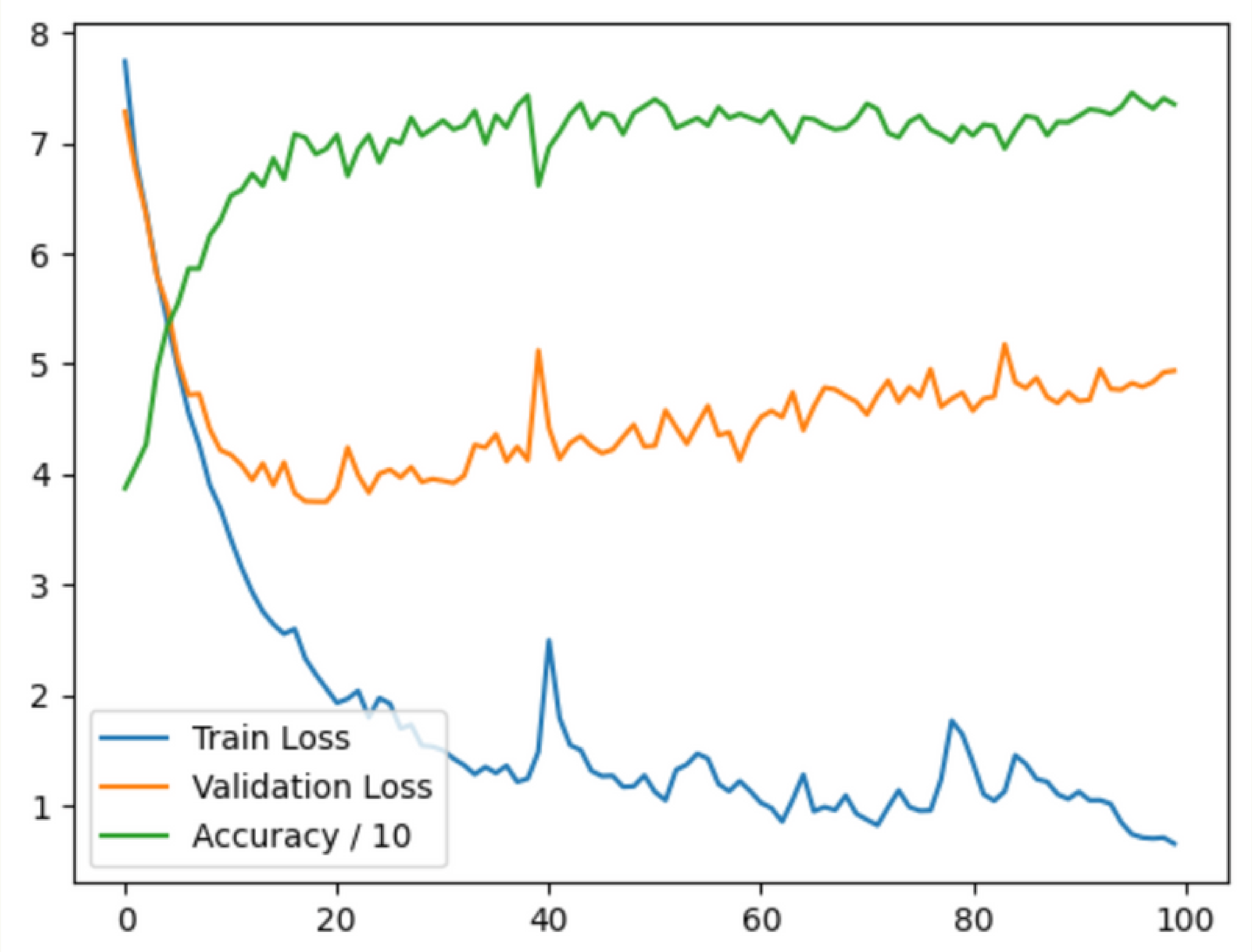
```
Epoch 86/100, trainingg loss:1.37, validation loss:4.78, accuracy:72.47%
Epoch 87/100, trainingg loss:1.24, validation loss:4.87, accuracy:72.29%
Epoch 88/100, trainingg loss:1.21, validation loss:4.70, accuracy:70.72%
Epoch 89/100, trainingg loss:1.10, validation loss:4.64, accuracy:71.93%
Epoch 90/100, trainingg loss:1.05, validation loss:4.74, accuracy:71.90%
Epoch 91/100, trainingg loss:1.12, validation loss:4.66, accuracy:72.47%
Epoch 92/100, trainingg loss:1.04, validation loss:4.67, accuracy:73.08%
Epoch 93/100, trainingg loss:1.04, validation loss:4.95, accuracy:72.95%
Epoch 94/100, trainingg loss:1.01, validation loss:4.77, accuracy:72.62%
Epoch 95/100, trainingg loss:0.84, validation loss:4.76, accuracy:73.29%
Epoch 96/100, trainingg loss:0.74, validation loss:4.83, accuracy:74.57%
Epoch 97/100, trainingg loss:0.70, validation loss:4.79, accuracy:73.76%
Epoch 98/100, trainingg loss:0.70, validation loss:4.84, accuracy:73.14%
Epoch 99/100, trainingg loss:0.71, validation loss:4.92, accuracy:74.07%
Epoch100/100, trainingg loss:0.65, validation loss:4.94, accuracy:73.53%
```

EVALUATION

PLOT THE LOSS AND ACCURACY

```
a = [i[0] for i in records]
b = [i[1] for i in records]
c = [i[2] * 10 for i in records]
plt.plot(a, '-', label = 'Train Loss')
plt.plot(b, '-', label = 'Validation Loss')
plt.plot(c, '-', label = 'Accuracy / 10')
plt.legend()
```

PLOT THE LOSS AND ACCURACY



Create Music

```
predict_steps = 3000

x = seed
x = np.expand_dims(x, axis = 0)

lstm.eval()
initi = lstm.initHidden(1)
predictions = []
for i in range(predict_steps):
    xx = torch.tensor(np.array(x, dtype = float),dtype = torch.float, requires_grad = True)
    preds = lstm(xx, initi)
    a,b,c = preds

    ind1 = torch.multinomial(a.view(-1).exp(), num_samples = 1)
    ind2 = torch.multinomial(b.view(-1).exp(), num_samples = 1)
    ind3 = torch.multinomial(c.view(-1).exp(), num_samples = 1)

    ind1 = ind1.data.numpy()[0]
    ind2 = ind2.data.numpy()[0]
    ind3 = ind3.data.numpy()[0]
```

Create Music

```
note = [ind1 + 24, ind2, 0 if ind3 ==0 else ind3 * interval + min_t]
predictions.append(note)

slot = np.zeros(89 + 128 + 12, dtype = int)
slot[ind1] = 1
slot[89 + ind2] = 1
slot[89 + 128 + ind3] = 1
slot1 = np.expand_dims(slot, axis = 0)
slot1 = np.expand_dims(slot1, axis = 0)

x = np.concatenate((x, slot1), 1)
x = x[:, 1:, :]
```

Load Create Music

```
mid = MidiFile()
track = MidiTrack()
mid.tracks.append(track)

for i, note in enumerate(predictions):
    note = np.insert(note, 0, 147)
    bytes = note.astype(int)
    msg = Message.from_bytes(bytes[0:3])
    time = int(note[3]/0.001025)
    msg.time = time
    track.append(msg)

mid.save('./new_song.mid')
```

DEMO

THANK YOU FOR LISTENING!