



PyTorch Tutorial

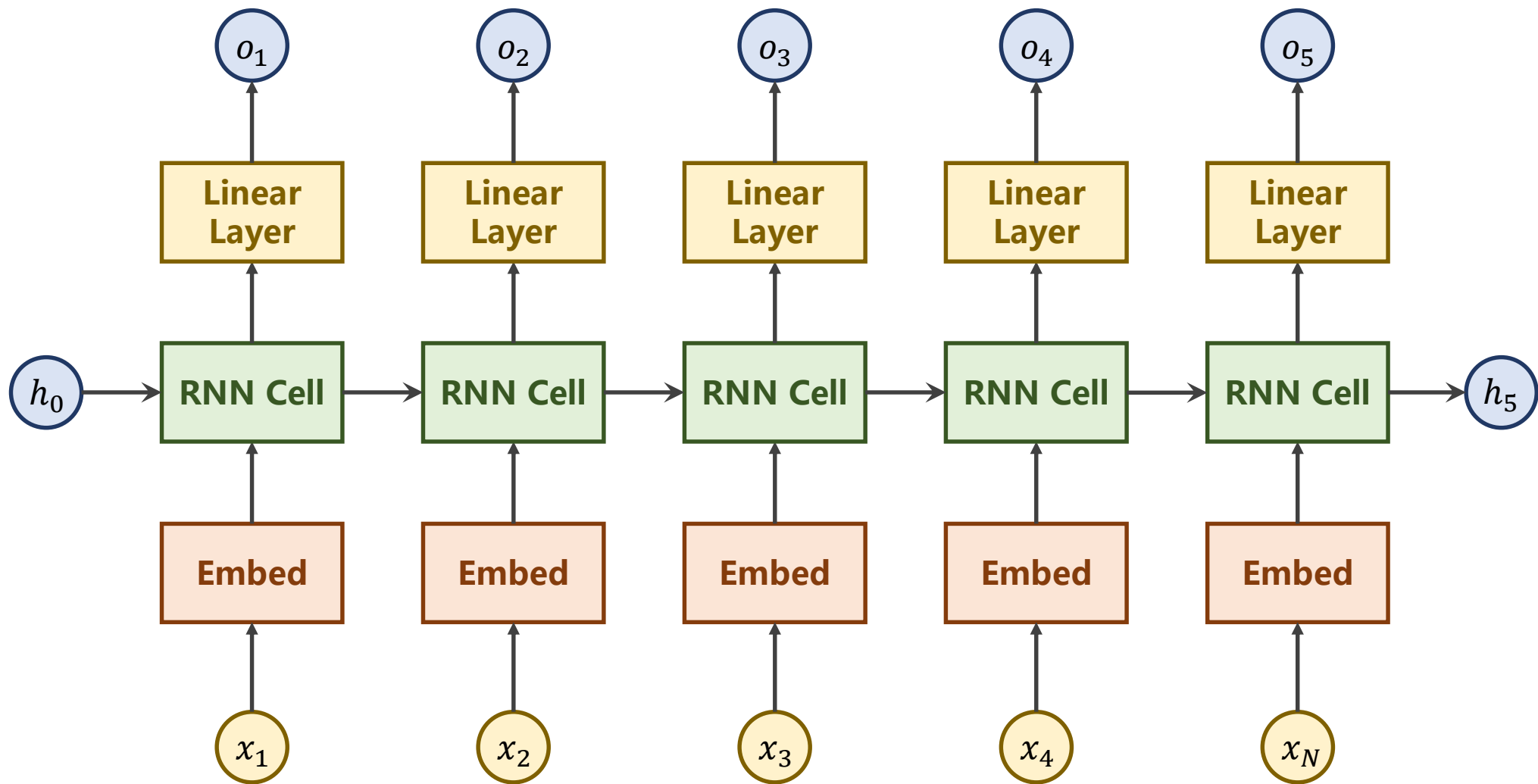
13. RNN Classifier

RNN Classifier – Name Classification

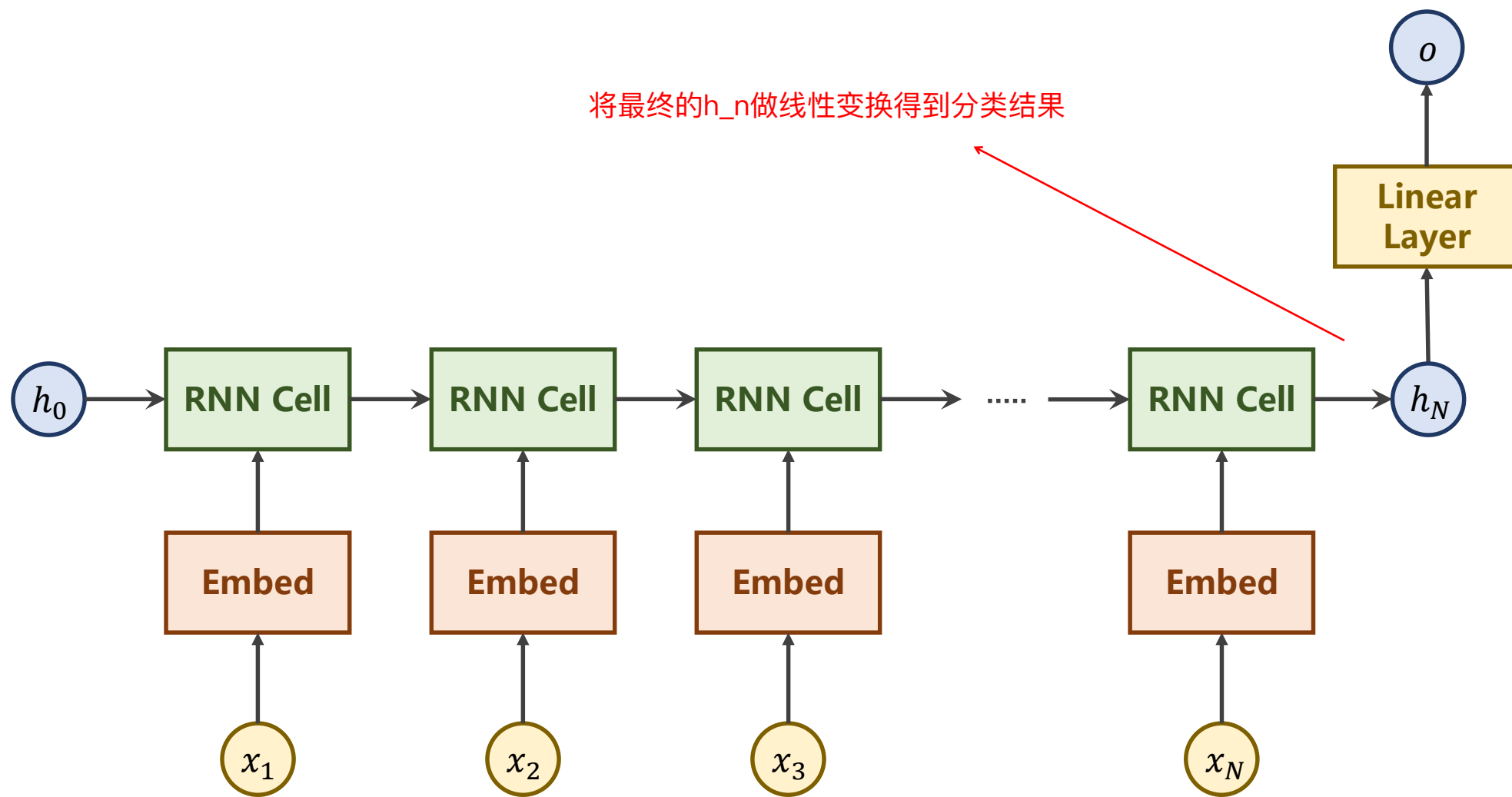
Name	Country
Maclean	English
Vajnichy	Russian
Nasikovsky	Russian
Usami	Japanese
Fionin	Russian
Sharkey	English
Balagul	Russian
Pakhrin	Russian
Tansho	Japanese

We shall train on a few thousand surnames from 18 languages of origin, and predict which language a name is from based on the spelling.

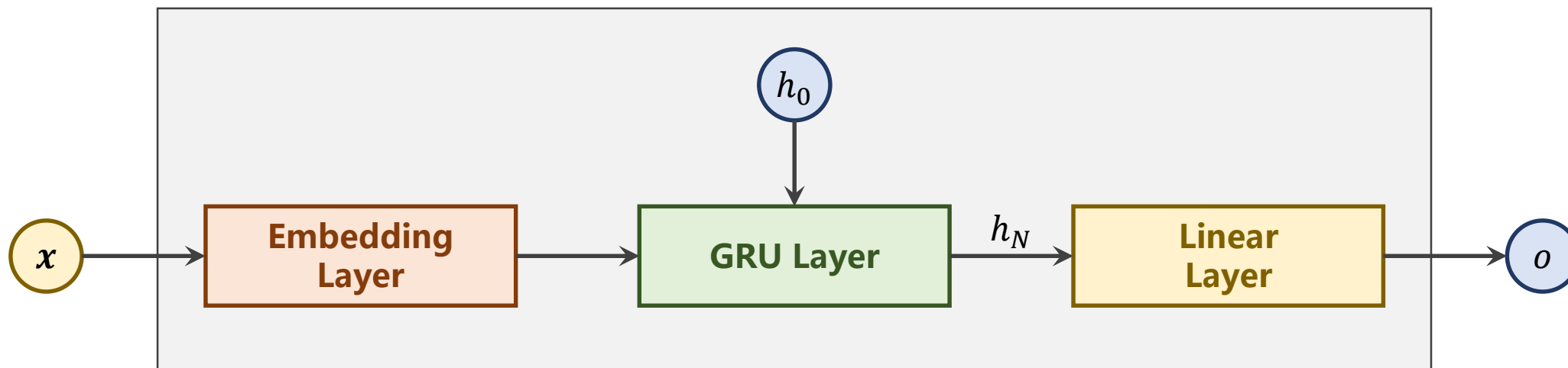
Revision



Our Model

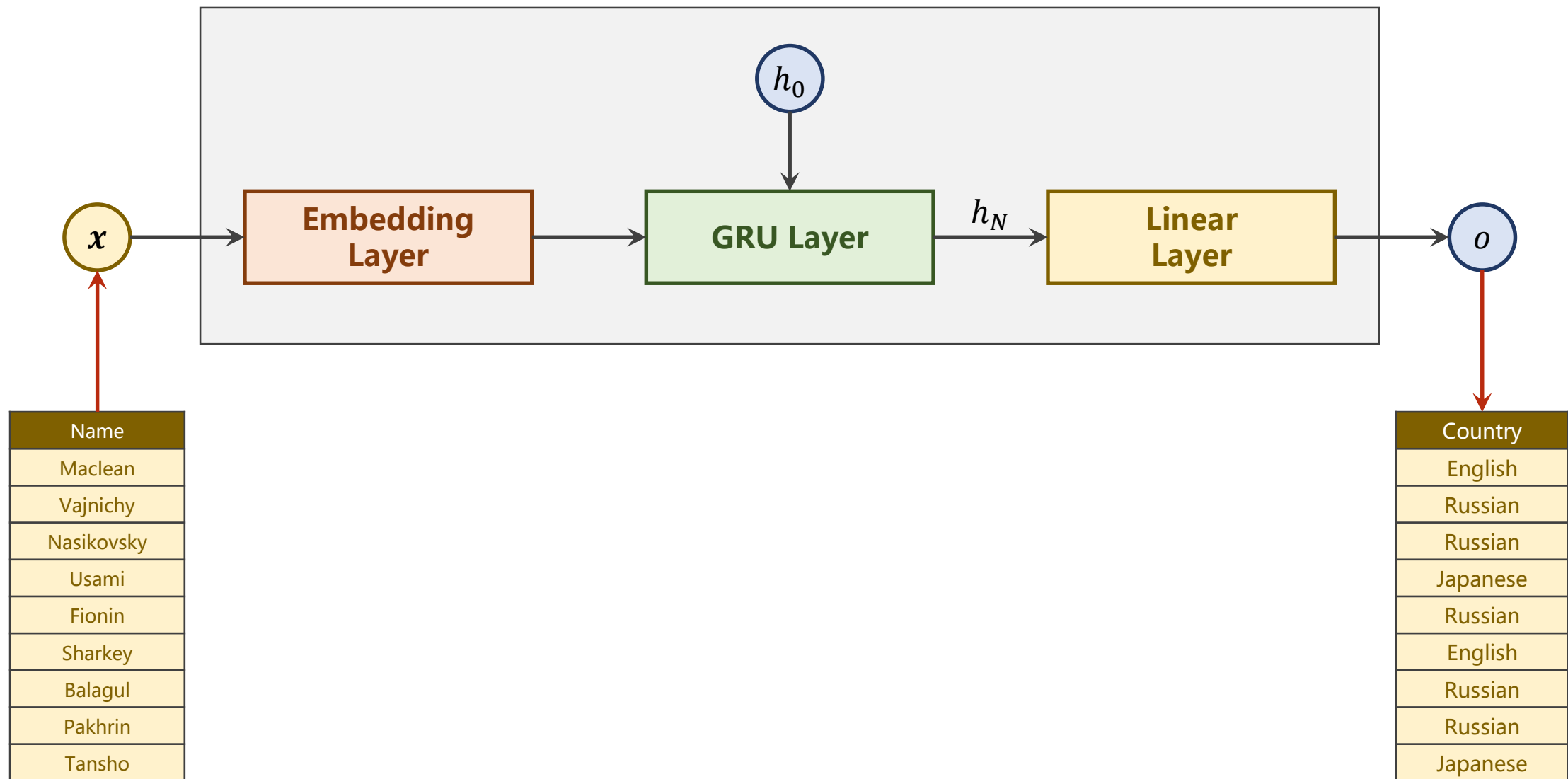


Our Model



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Nasikovsky	Russian
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Fionin	Russian
Sharkey	English
Balagul	Russian
Pakhrin	Russian
Tansho	Japanese

Our Model



Implementation – Main Cycle

```
if __name__ == '__main__':  
    classifier = RNNClassifier(N_CHARS, HIDDEN_SIZE, N_COUNTRY, N_LAYER)  
    if USE_GPU:  
        device = torch.device("cuda:0")  
        classifier.to(device)  
  
    criterion = torch.nn.CrossEntropyLoss()  
    optimizer = torch.optim.Adam(classifier.parameters(), lr=0.001)  
  
    start = time.time()  
    print("Training for %d epochs..." % N_EPOCHS)  
    acc_list = []  
    for epoch in range(1, N_EPOCHS + 1):  
        # Train cycle  
        trainModel()  
        acc = testModel()  
        acc_list.append(acc)
```

Instantiate the classifier model.

Implementation – Main Cycle

```
if __name__ == '__main__':
    classifier = RNNClassifier(N_CHARS, HIDDEN_SIZE, N_COUNTRY, N_LAYER)
    if USE_GPU:
        device = torch.device("cuda:0")
        classifier.to(device)

    criterion = torch.nn.CrossEntropyLoss()
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    print("Training for %d epochs..." % N_EPOCHS)
    acc_list = []
    for epoch in range(1, N_EPOCHS + 1):
        # Train cycle
        trainModel()
        acc = testModel()
        acc_list.append(acc)
```

Whether use GPU for training model.

Implementation – Main Cycle

```
if __name__ == '__main__':
    classifier = RNNClassifier(N_CHARS, HIDDEN_SIZE, N_COUNTRY, N_LAYER)
    if USE_GPU:
        device = torch.device("cuda:0")
        classifier.to(device)

    criterion = torch.nn.CrossEntropyLoss()
    optimizer = torch.optim.Adam(classifier.parameters(), lr=0.001)

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        # Train cycle
        trainModel()
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        acc_list.append(acc)
```

Using cross entropy loss
as loss function.
Using Adam optimizer.

Implementation – Main Cycle

```
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    if USE_GPU:
        device = torch.device("cuda:0")
        classifier.to(device)

    criterion = torch.nn.CrossEntropyLoss()
    optimizer = torch.optim.Adam(classifier.parameters(), lr=0.001)

    start = time.time()
    print("Training for %d epochs..." % N_EPOCHS)
    acc_list = []
    for epoch in range(1, N_EPOCHS + 1):
        # Train cycle
        trainModel()
        acc = testModel()
        acc_list.append(acc)
```

For printing elapsed time.

```
def time_since(since):
    s = time.time() - since
    m = math.floor(s / 60)
    s -= m * 60
    return '%dm %ds' % (m, s)
```

Implementation – Main Cycle

```
if __name__ == '__main__':
    classifier = RNNClassifier(N_CHARS, HIDDEN_SIZE, N_COUNTRY, N_LAYER)
    if USE_GPU:
        device = torch.device("cuda:0")
        classifier.to(device)

    criterion = torch.nn.CrossEntropyLoss()
    optimizer = torch.optim.Adam(classifier.parameters(), lr=0.001)

    start = time.time()
    print("Training for %d epochs..." % N_EPOCHS)
    acc_list = []
    for epoch in range(1, N_EPOCHS + 1):
        # Train cycle
        trainModel()
        acc = testModel()
        acc_list.append(acc)
```

In every epoch, training and testing the model once.

Implementation – Main Cycle

```
if __name__ == '__main__':
    classifier = RNNClassifier(N_CHARS, HIDDEN_SIZE, N_COUNTRY, N_LAYER)
    if USE_GPU:
        device = torch.device("cuda:0")
        classifier.to(device)

    criterion = torch.nn.CrossEntropyLoss()
    optimizer = torch.optim.Adam(classifier.parameters(), lr=0.001)

    start = time.time()
    print("Training for %d epochs..." % N_EPOCHS)
    acc_list = []
    for epoch in range(1, N_EPOCHS + 1):
        # Train cycle
        trainModel()
        acc = testModel()
        acc_list.append(acc)
```

Recording the accuracy
of testing.

```
import matplotlib.pyplot as plt
import numpy as np

epoch = np.arange(1, len(acc_list) + 1, 1)
acc_list = np.array(acc_list)
plt.plot(epoch, acc_list)
plt.xlabel('Epoch')
plt.ylabel('Accuracy')
plt.grid()
plt.show()
```

Implementation – Preparing Data

Name	Characters	ASCII
Maclean	['M', 'a', 'c', 'l', 'e', 'a', 'n']	[77 97 99 108 101 97 110]
Vajnichy	['V', 'a', 'j', 'n', 'i', 'c', 'h', 'y']	[86 97 106 110 105 99 104 121]
Nasikovsky	['N', 'a', 's', 'i', 'k', 'o', 'v', 's', 'k', 'y']	[78 97 115 105 107 111 118 115 107 121]
Usami	['U', 's', 'a', 'm', 'i']	[85 115 97 109 105]
Fionin	['F', 'i', 'o', 'n', 'i', 'n']	[70 105 111 110 105 110]
Sharkey	['S', 'h', 'a', 'r', 'k', 'e', 'y']	[83 104 97 114 107 101 121]
Balagul	['B', 'a', 'l', 'a', 'g', 'u', 'l']	[66 97 108 97 103 117 108]
Pakhrin	['P', 'a', 'k', 'h', 'r', 'i', 'n']	[80 97 107 104 114 105 110]
Tansho	['T', 'a', 'n', 's', 'h', 'o']	[84 97 110 115 104 111]

Implementation – Preparing Data

ASCII
[77 97 99 108 101 97 110]
[86 97 106 110 105 99 104 121]
[78 97 115 105 107 111 118 115 107 121]
[85 115 97 109 105]
[70 105 111 110 105 110]
[83 104 97 114 107 101 121]
[66 97 108 97 103 117 108]
[80 97 107 104 114 105 110]
[84 97 110 115 104 111]



After padding
[77 97 99 108 101 97 110 0 0 0]
[86 97 106 110 105 99 104 121 0 0]
[78 97 115 105 107 111 118 115 107 121]
[85 115 97 109 105 0 0 0 0 0]
[70 105 111 110 105 110 0 0 0 0]
[83 104 97 114 107 101 121 0 0 0]
[66 97 108 97 103 117 108 0 0 0]
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Implementation – Preparing Data

Country	Index	Country	Index
Arabic	0	Chinese	1
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Polish	12	Portuguese	13
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Spanish	16	Vietnamese	17

Implementation – Preparing Data

Reading data from .gz file with package *gzip* and *csv*.

```
import gzip
import csv
```

```
class NameDataset(Dataset):
    def __init__(self, is_train_set=True):
        filename = 'data/names_train.csv.gz' if is_train_set else 'data/names_test.csv.gz'
        with gzip.open(filename, 'rt') as f:
            reader = csv.reader(f)
            rows = list(reader)
        self.names = [row[0] for row in rows]
        self.len = len(self.names)
        self.countries = [row[1] for row in rows]
        self.country_list = list(sorted(set(self.countries)))
        self.country_dict = self.getCountryDict()
        self.country_num = len(self.country_list)

    def __getitem__(self, index):
        return self.names[index], self.country_dict[self.countries[index]]

    def __len__(self):
        return self.len
```


Implementation – Preparing Data

Save names and countries in *list*.

```
class NameDataset(Dataset):
    def __init__(self, is_train_set=True):
        filename = 'data/names_train.csv.gz' if is_train_set else 'data/names_test.csv.gz'
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```

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Maclean	English
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Implementation – Preparing Data

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Save countries and its index in *list* and *dictionary*.

Implementation – Preparing Data

```
class NameDataset(Dataset):
```

```
    def __init__(self, is_train:
```

```
        filename = 'data/names
```

```
        with gzip.open(filename,
```

```
            reader = csv.reader
```

```
            rows = list(reader
```

```
        self.names = [row[0] f
```

```
        self.len = len(self.na
```

```
        self.countries = [row
```

```
        self.country_list = list(sorted(set(self.countries)))
```

```
        self.country_dict = self.getCountryDict()
```

```
        self.country_num = len(self.country_list)
```

```
    def __getitem__(self, index):
```

```
        ← return self.names[index], self.country_dict[self.countries[index]]
```

```
    def __len__(self):
```

```
        return self.len
```

Name	Country
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train

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.gz'

Save countries and its index in *list* and *dictionary*.

Implementation – Preparing Data

```
class NameDataset(Dataset):
```

```
    def __init__(self, is_train:
```

```
        filename = 'data/names
```

```
        with gzip.open(filename,
```

```
            reader = csv.reader
```

```
            rows = list(reader
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        self.names = [row[0] f
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        self.country_dict = self.getCountryDict()
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```
        self.country_num = len(self.country_list)
```

```
    def __getitem__(self, index):
```

```
    ← return self.names[index], self.country_dict[self.countries[index]]
```

```
    def __len__(self):
```

```
        return self.len
```

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train

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.gz'

Save countries and its
index in *list* and
dictionary.

Implementation – Preparing Data

```
class NameDataset(Dataset):
    def __init__(self, is_train_set=True):
        filename = 'data/names_train.csv.gz' if is_train_set else 'data/names_test.csv.gz'
        with gzip.open(filename, 'rt') as f:
            reader = csv.reader(f)
            rows = list(reader)
            self.names = [row[0] for row in rows]
            self.len = len(self.names)
            self.countries = [row[1] for row in rows]
            self.country_list = list(sorted(set(self.countries)))
            self.country_dict = self.getCountryDict()
            self.country_num = len(self.country_list)

    def __getitem__(self, index):
        return self.names[index], self.country_dict[self.countries[index]]

    def __len__(self):
        ← return self.len
```

Return length of
dataset.

Implementation – Preparing Data

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Arabic	0	Chinese	1
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Irish	8	Italian	9
Japanese	10	Korean	11
Polish			
Russian			
Spanish			

Convert *list* into
dictionary.

```
class NameDataset(Dataset):  
  
    .....  
  
    def getCountryDict(self):  
        country_dict = dict()  
        for idx, country_name in enumerate(self.country_list, 0):  
            country_dict[country_name] = idx  
        return country_dict  
  
    def idx2country(self, index):  
        return self.country_list[index]  
  
    def getCountriesNum(self):  
        return self.country_num
```

Implementation – Preparing Data

Country	Index	Country	Index
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Polish	12	Portuguese	13
Russian	14	Scottish	15
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Return country name
giving index.

```
class NameDataset(Dataset):  
  
    .....  
  
    def getCountryDict(self):  
        country_dict = dict()  
        for idx, country_name in enumerate(self.country_list, 0):  
            country_dict[country_name] = idx  
        return country_dict  
  
    def idx2country(self, index):  
        return self.country_list[index]  
  
    def getCountriesNum(self):  
        return self.country_num
```

Implementation – Preparing Data

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Polish	12	Portuguese	13
Russian	14	Scottish	15
Spanish	16	Vietnamese	17

Return the number of countries.

```
class NameDataset(Dataset):  
  
    .....  
  
    def getCountryDict(self):  
        country_dict = dict()  
        for idx, country_name in enumerate(self.country_list, 0):  
            country_dict[country_name] = idx  
        return country_dict  
  
    def idx2country(self, index):  
        return self.country_list[index]  
  
    def getCountriesNum(self):  
        return self.country_num
```


Implementation – Preparing Data

```
trainset = NameDataset(is_train_set=True)
trainloader = DataLoader(trainset, batch_size=BATCH_SIZE, shuffle=True)
testset = NameDataset(is_train_set=False)
testloader = DataLoader(testset, batch_size=BATCH_SIZE, shuffle=False)

N_COUNTRY = trainset.getCountriesNum()
```

Prepare Dataset and DataLoader

Implementation – Preparing Data

```
trainset = NameDataset(is_train_set=True)
trainloader = DataLoader(trainset, batch_size=BATCH_SIZE, shuffle=True)
testset = NameDataset(is_train_set=False)
testloader = DataLoader(testset, batch_size=BATCH_SIZE, shuffle=False)

N_COUNTRY = trainset.getCountriesNum()
```

N_COUNTRY is the output size of our model.

Implementation – Preparing Data

```
trainset = NameDataset(is_train_set=True)
trainloader = DataLoader(trainset, batch_size=BATCH_SIZE,
testset = NameDataset(is_train_set=False)
testloader = DataLoader(testset, batch_size=BATCH_SIZE, shuffle=False)

N_COUNTRY = trainset.getCountriesNum()
```

Parameters

HIDDEN_SIZE = 100

BATCH_SIZE = 256

N_LAYER = 2

N_EPOCHS = 100

N_CHARS = 128

USE_GPU = False

N_COUNTRY is the output size of our model.

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, output_size, n_layers=1, bidirectional=True):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.n_layers = n_layers
        self.n_directions = 2 if bidirectional else 1

        self.embedding = torch.nn.Embedding(input_size, hidden_size)
        self.gru = torch.nn.GRU(hidden_size, hidden_size, n_layers,
                                bidirectional=bidirectional)
        self.fc = torch.nn.Linear(hidden_size * self.n_directions, output_size)

    def _init_hidden(self, batch_size):
        hidden = torch.zeros(self.n_layers * self.n_directions,
                              batch_size, self.hidden_size)
        return create_tensor(hidden)
```

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, output_size, n_layers=1, bidirectional=True):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
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        self.gru = torch.nn.GRU(hidden_size, hidden_size, n_layers,
                                bidirectional=bidirectional)
        self.fc = torch.nn.Linear(hidden_size * self.n_directions, output_size)

    def _init_hidden(self, batch_size):
        hidden = torch.zeros(self.n_layers * self.n_directions,
                              batch_size, self.hidden_size)
        return create_tensor(hidden)
```

Parameters of GRU layer.

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, output_size, n_layers,
                  bidirectional):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.n_layers = n_layers
        self.n_directions = 2 if bidirectional else 1

        self.embedding = torch.nn.Embedding(input_size, hidden_size)
        self.gru = torch.nn.GRU(hidden_size, hidden_size, n_layers,
                                bidirectional=bidirectional)
        self.fc = torch.nn.Linear(hidden_size * self.n_directions, output_size)

    def _init_hidden(self, batch_size):
        hidden = torch.zeros(self.n_layers * self.n_directions,
                              batch_size, self.hidden_size)
        return create_tensor(hidden)
```

The input of Embedding Layer with shape:

$(seqLen, batchSize)$

The output of Embedding Layer with shape:

$(seqLen, batchSize, hiddenSize)$

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, n_layers, n_directions=2, bidirectional=True, output_size):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.n_layers = n_layers
        self.n_directions = n_directions
        self.bidirectional = bidirectional

        self.embedding = torch.nn.Embedding(input_size, hidden_size)
        self.gru = torch.nn.GRU(hidden_size, hidden_size, n_layers, batch_first=True, bidirectional=bidirectional)
        self.fc = torch.nn.Linear(hidden_size * self.n_directions, output_size)

    def _init_hidden(self, batch_size):
        hidden = torch.zeros(self.n_layers * self.n_directions, batch_size, self.hidden_size)
        return create_tensor(hidden)
```

The **inputs** of GRU Layer with shape:

input: (seqLen, batchSize, hiddenSize)

*hidden: (nLayers * nDirections, batchSize, hiddenSize)*

The **outputs** of GRU Layer with shape:

*output: (seqLen, batchSize, hiddenSize * nDirections)*

*hidden: (nLayers * nDirections, batchSize, hiddenSize)*

Implementation – Model Design

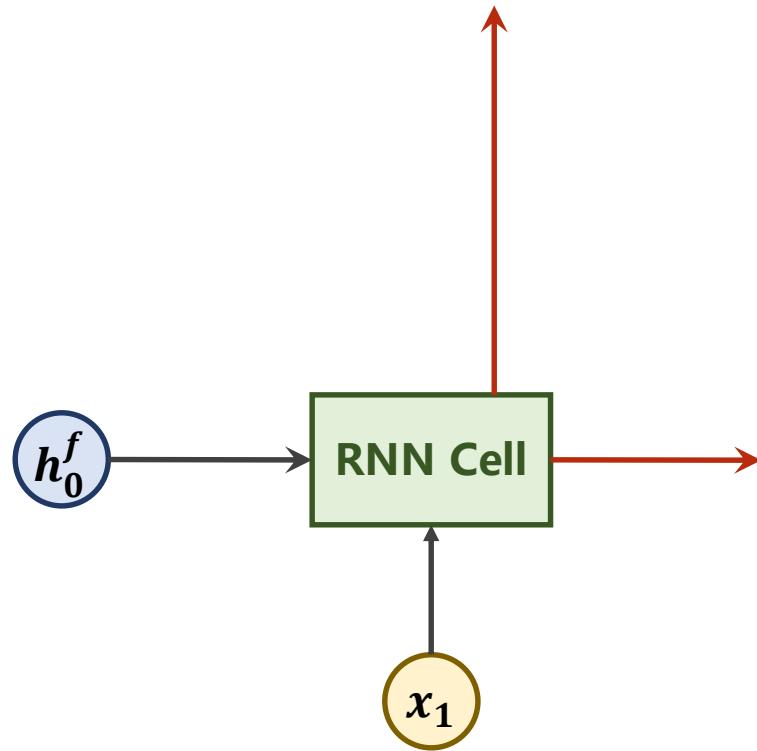
```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, output_size, n_layers=1, bidirectional=True):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.n_layers = n_layers
        self.n_directions = 2 if bidirectional else 1

        self.embedding = torch.nn.Embedding(input_size, hidden_size)
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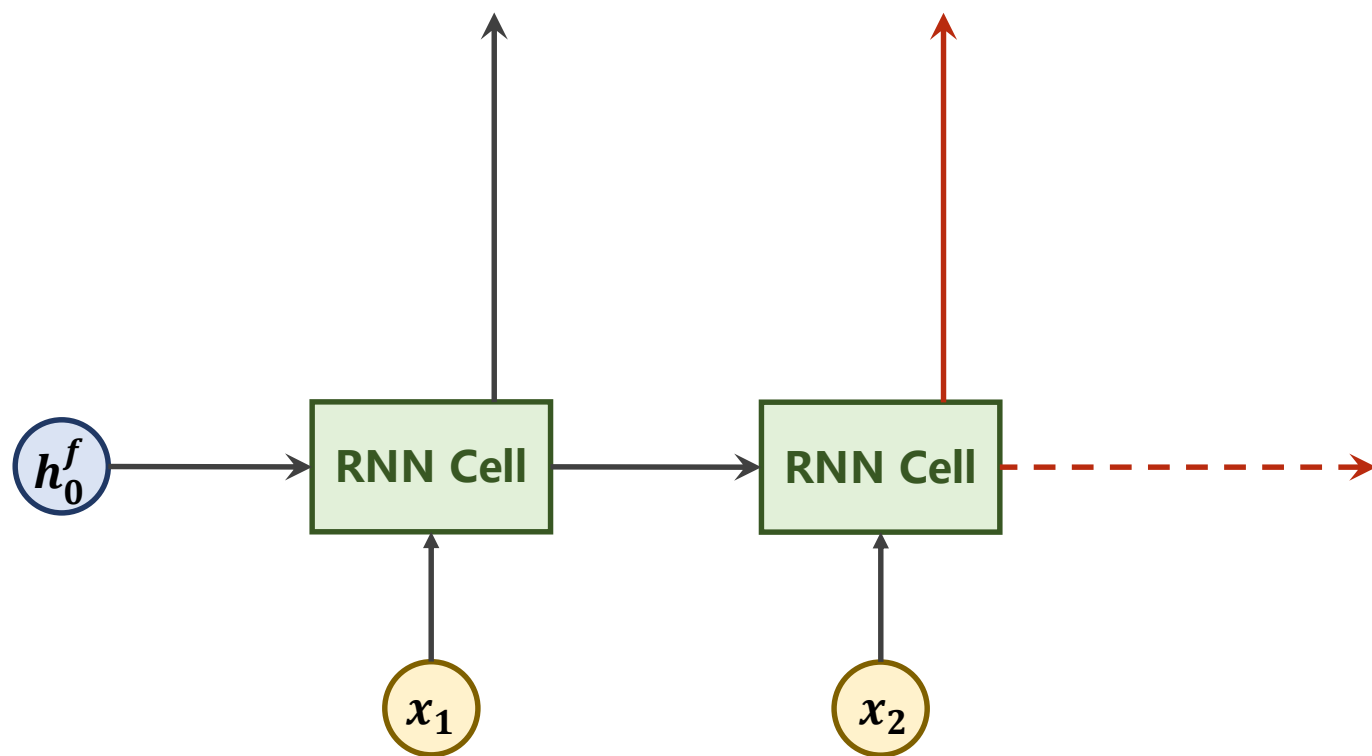
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        hidden = torch.zeros(self.n_layers * self.n_directions,
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```

What is the Bi-Direction RNN/LSTM/GRU?

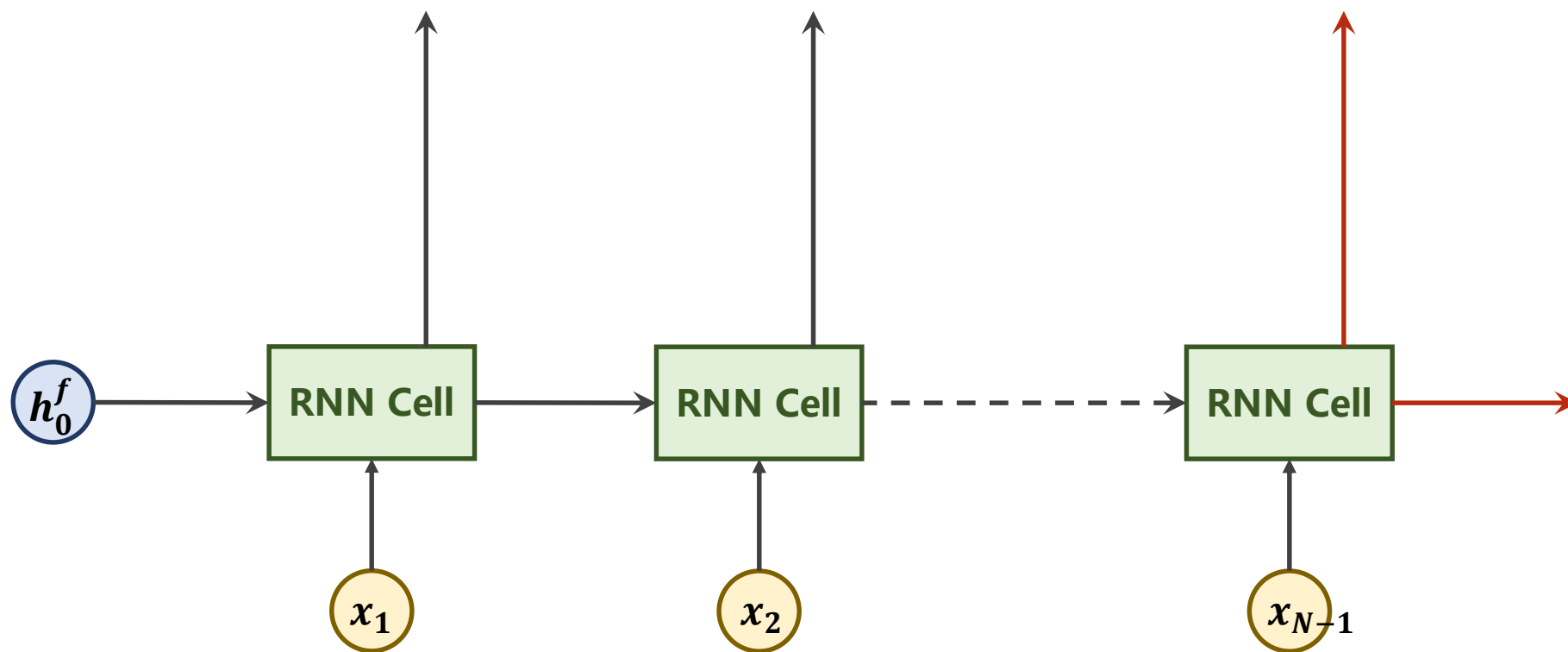
Implementation – Bi-direction RNN/LSTM/GRU



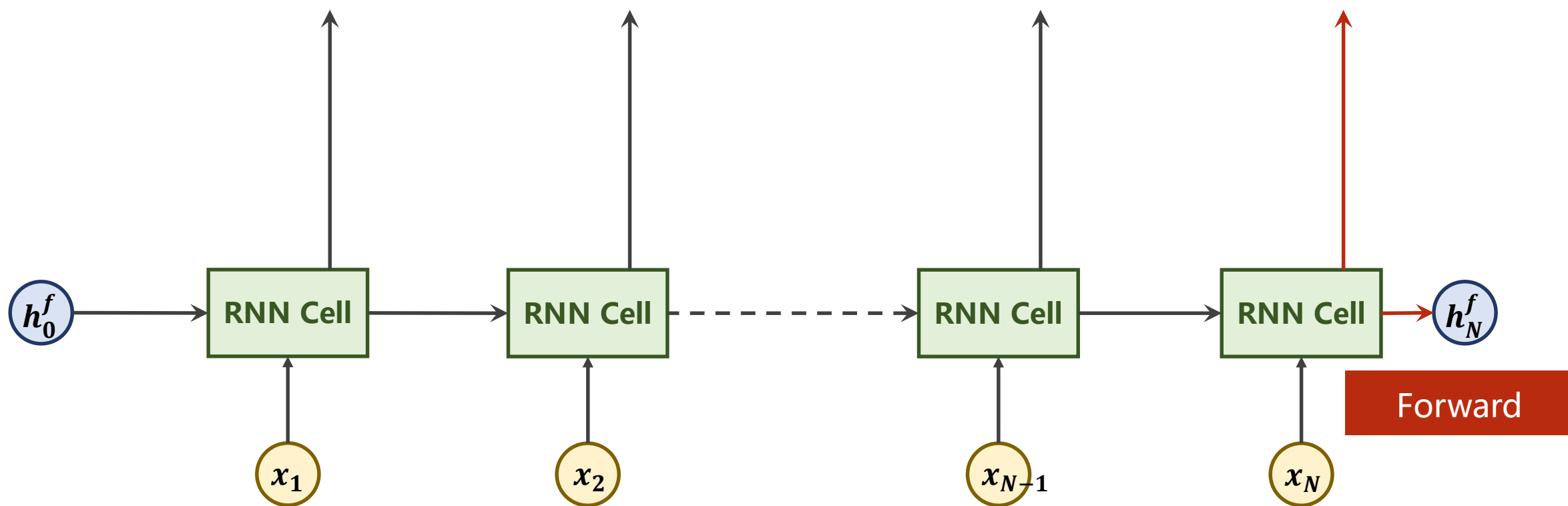
Implementation – Bi-direction RNN/LSTM/GRU



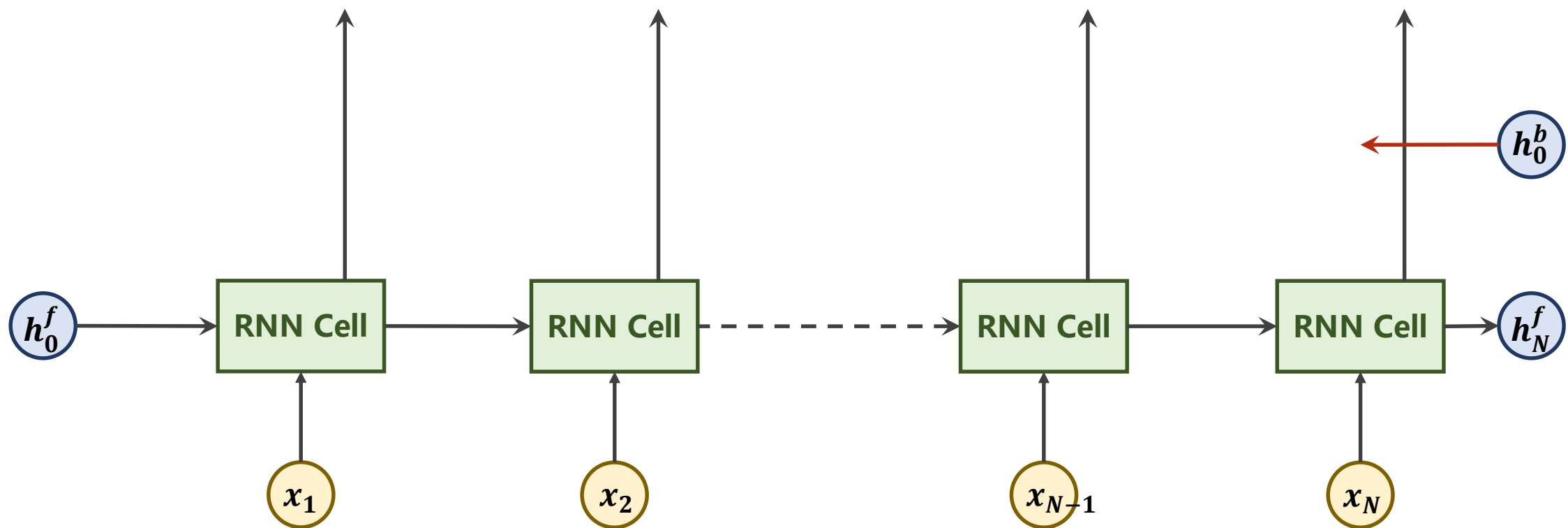
Implementation – Bi-direction RNN/LSTM/GRU



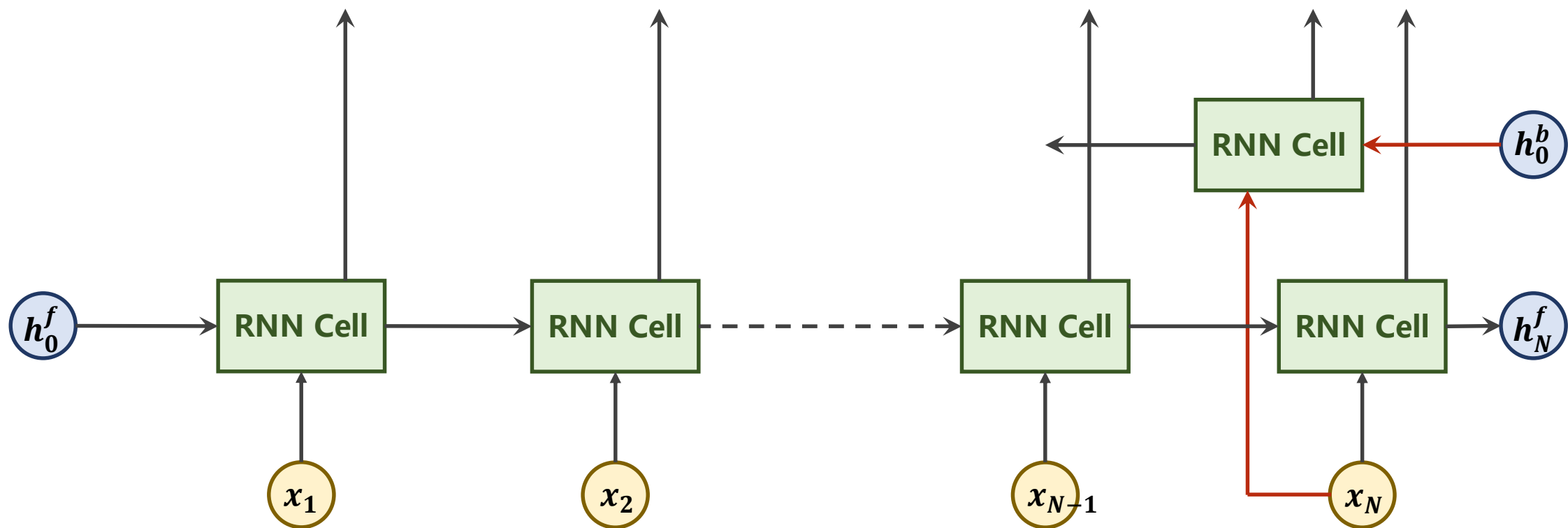
Implementation – Bi-direction RNN/LSTM/GRU



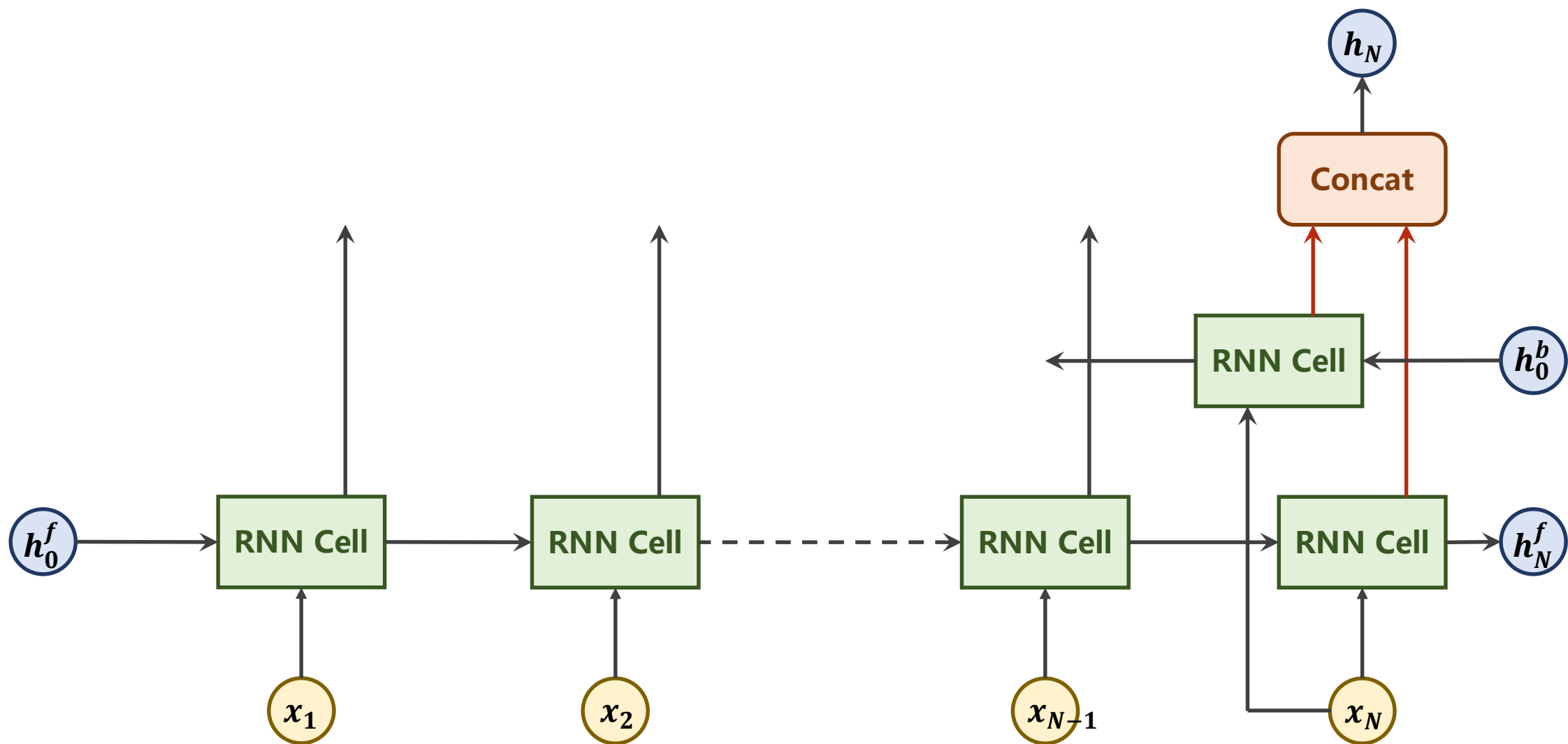
Implementation – Bi-direction RNN/LSTM/GRU



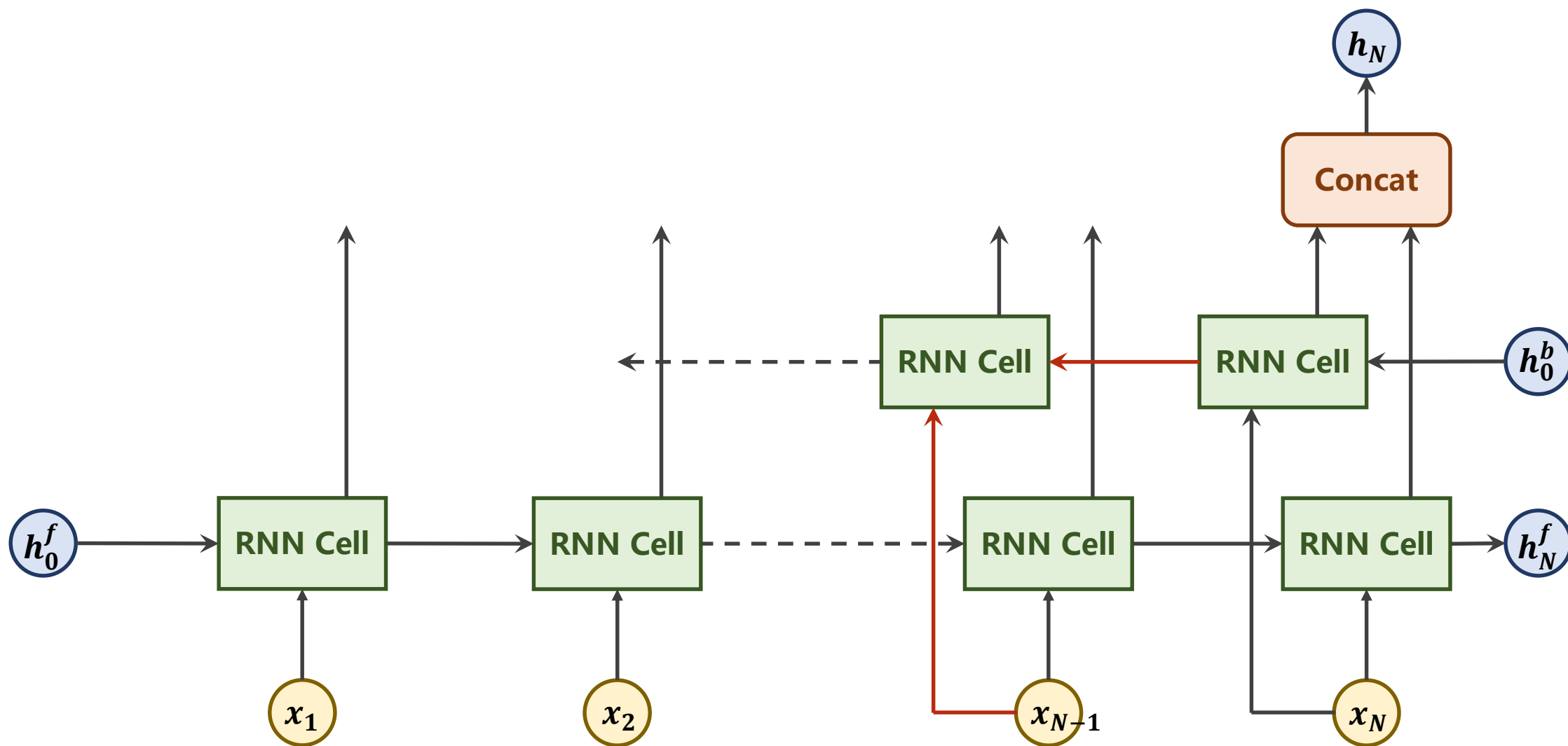
Implementation – Bi-direction RNN/LSTM/GRU



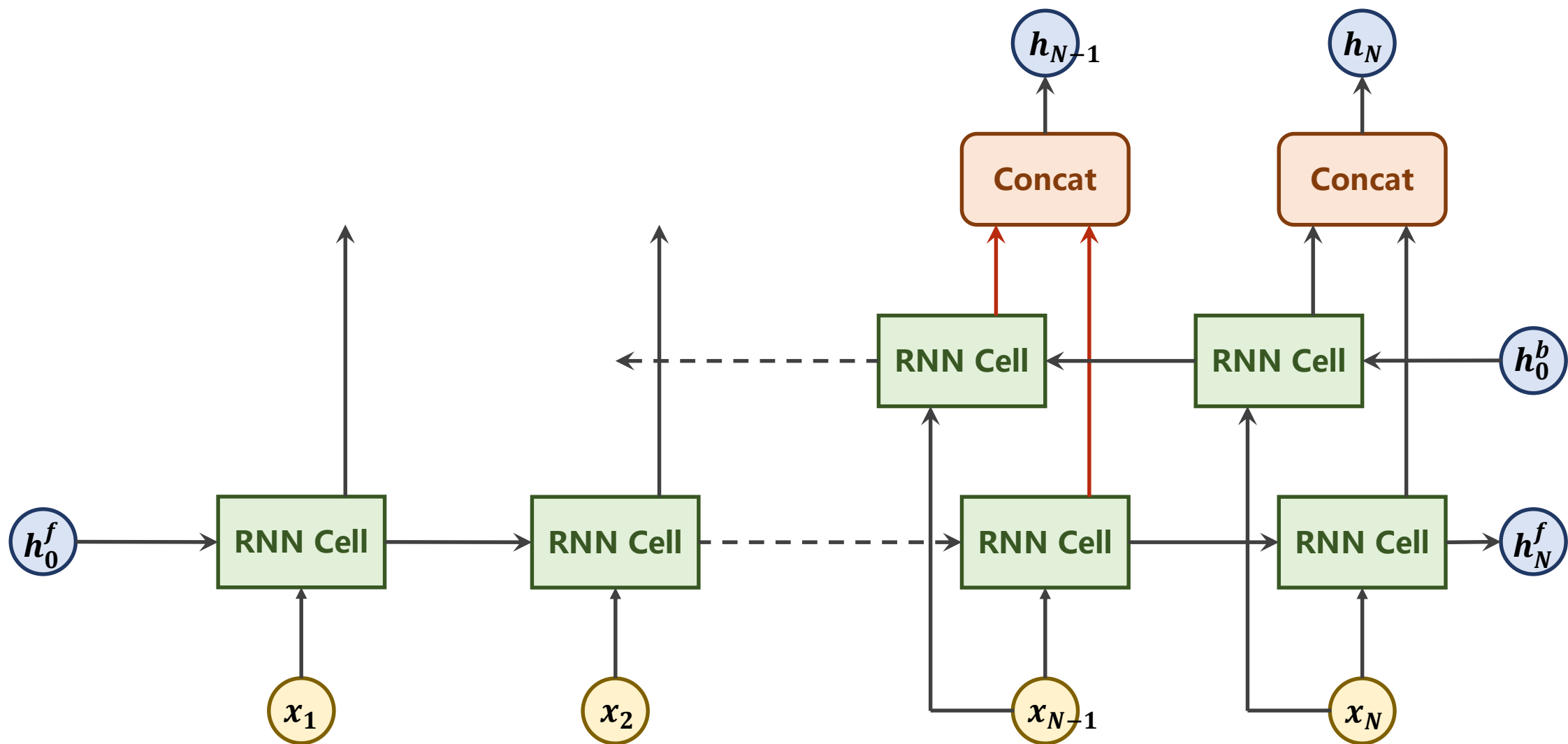
Implementation – Bi-direction RNN/LSTM/GRU



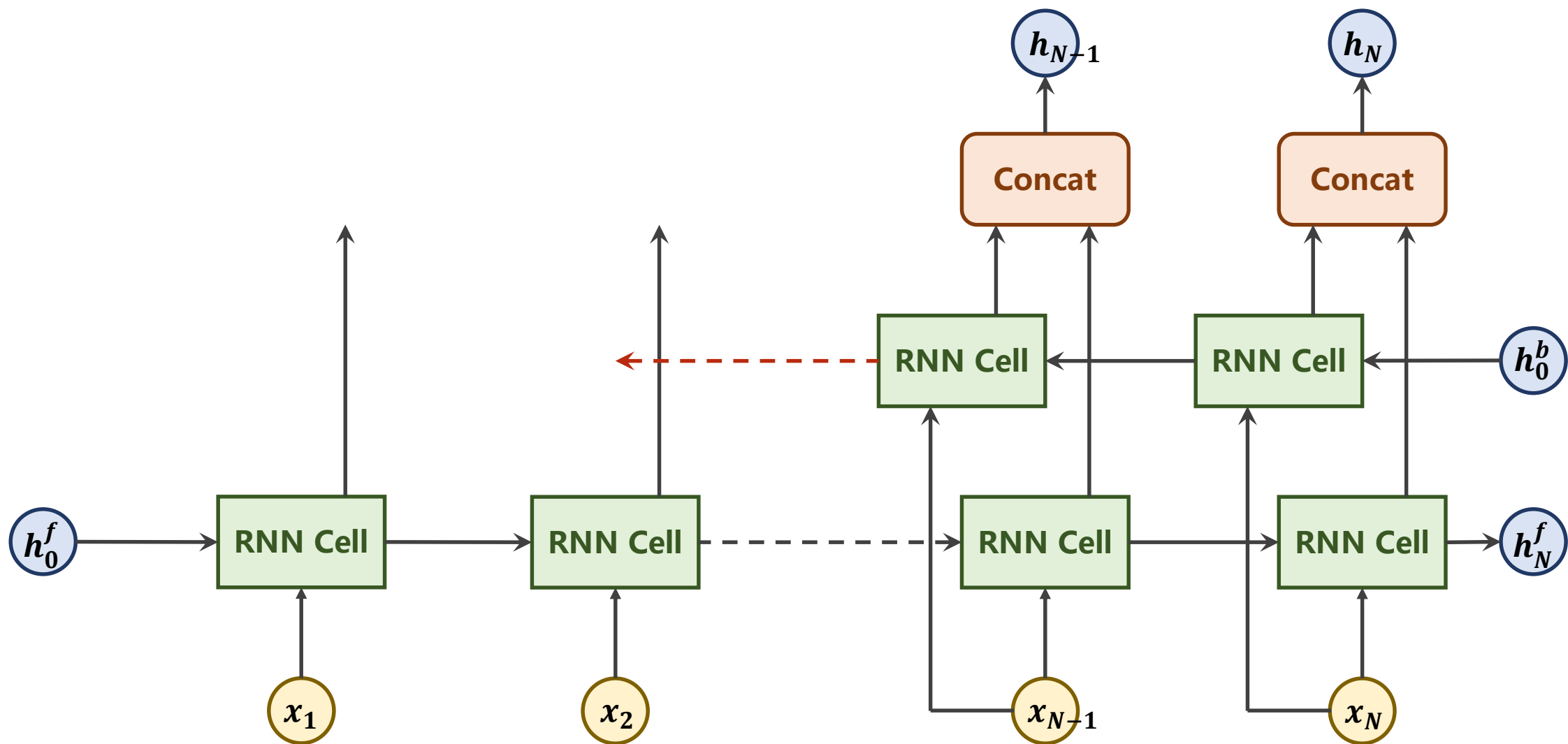
Implementation – Bi-direction RNN/LSTM/GRU



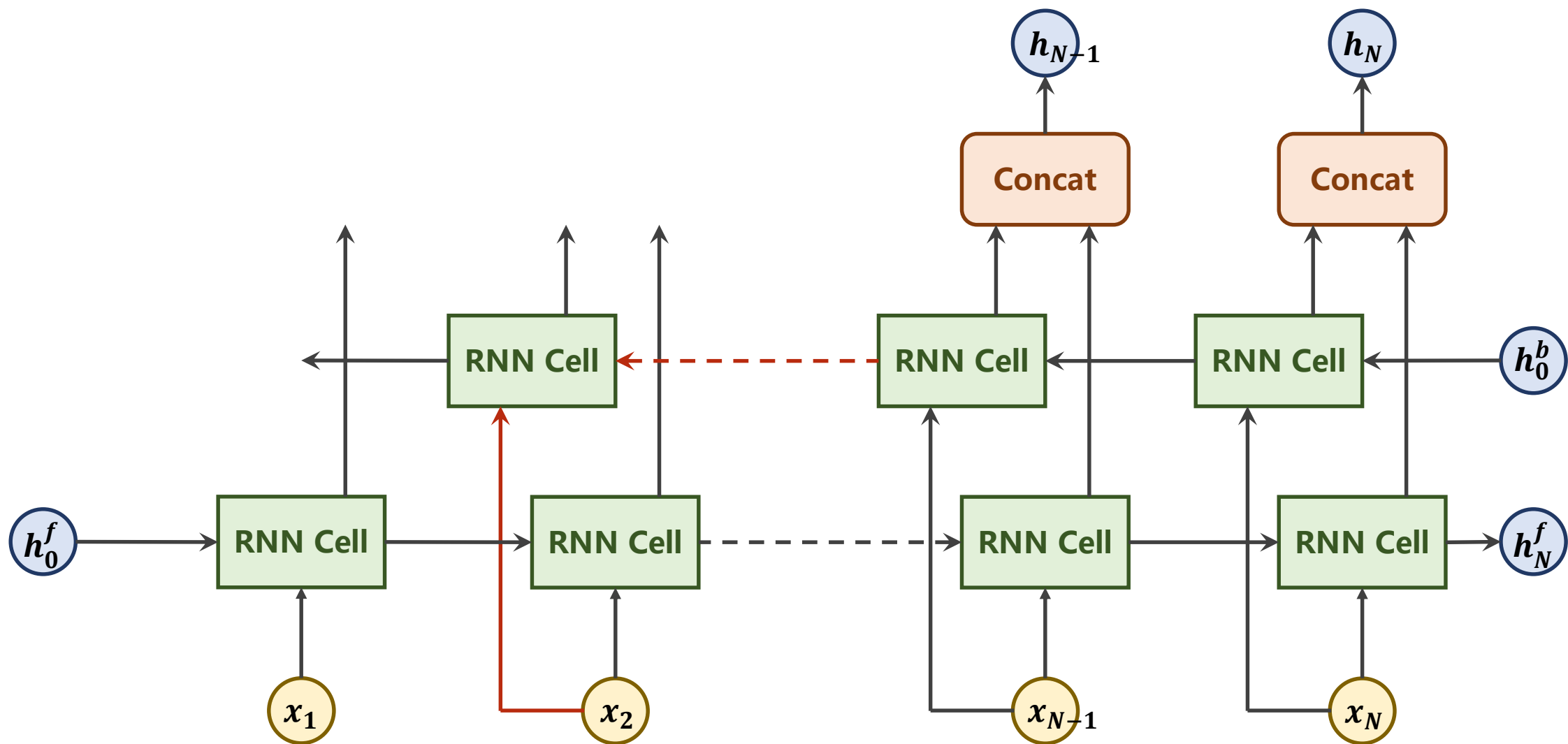
Implementation – Bi-direction RNN/LSTM/GRU



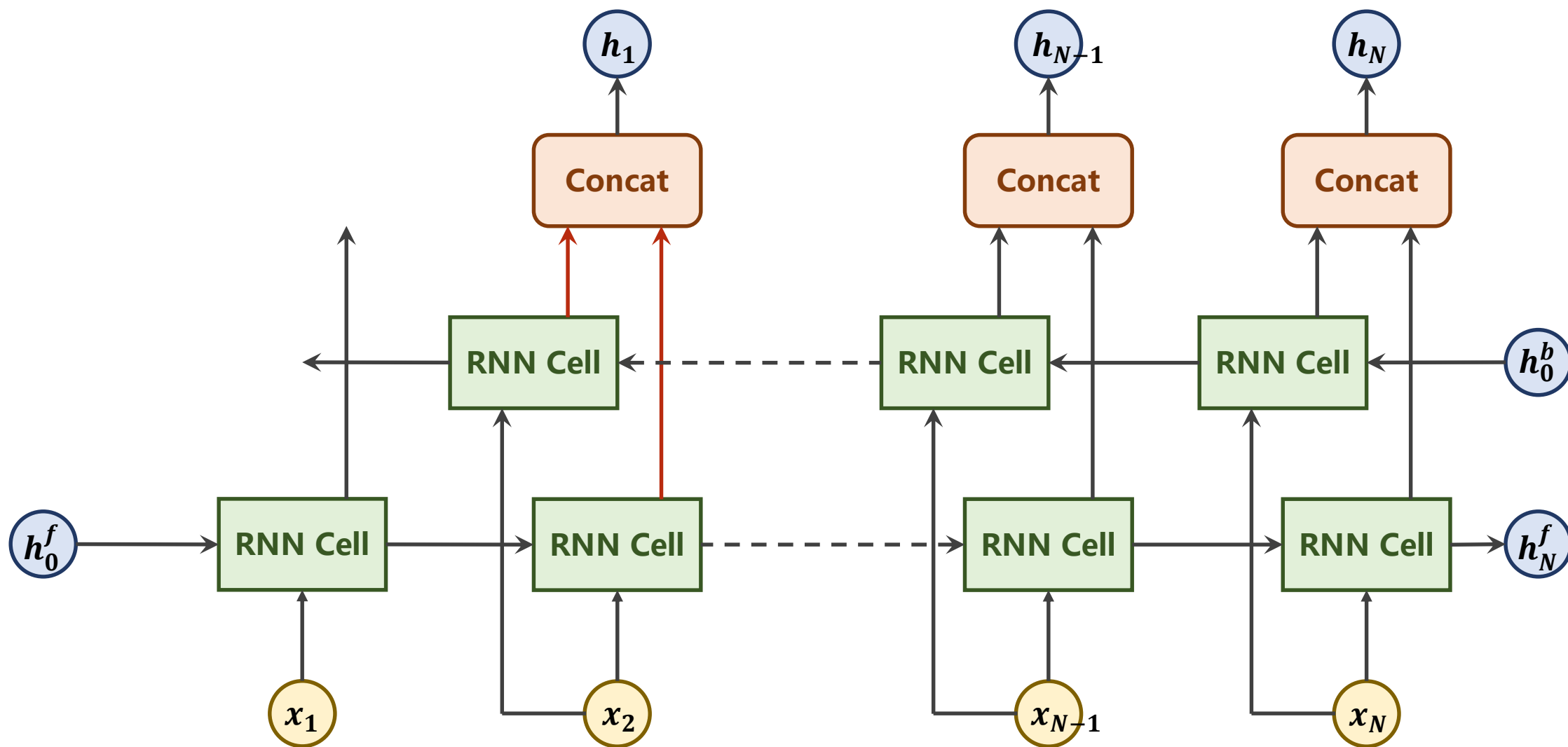
Implementation – Bi-direction RNN/LSTM/GRU



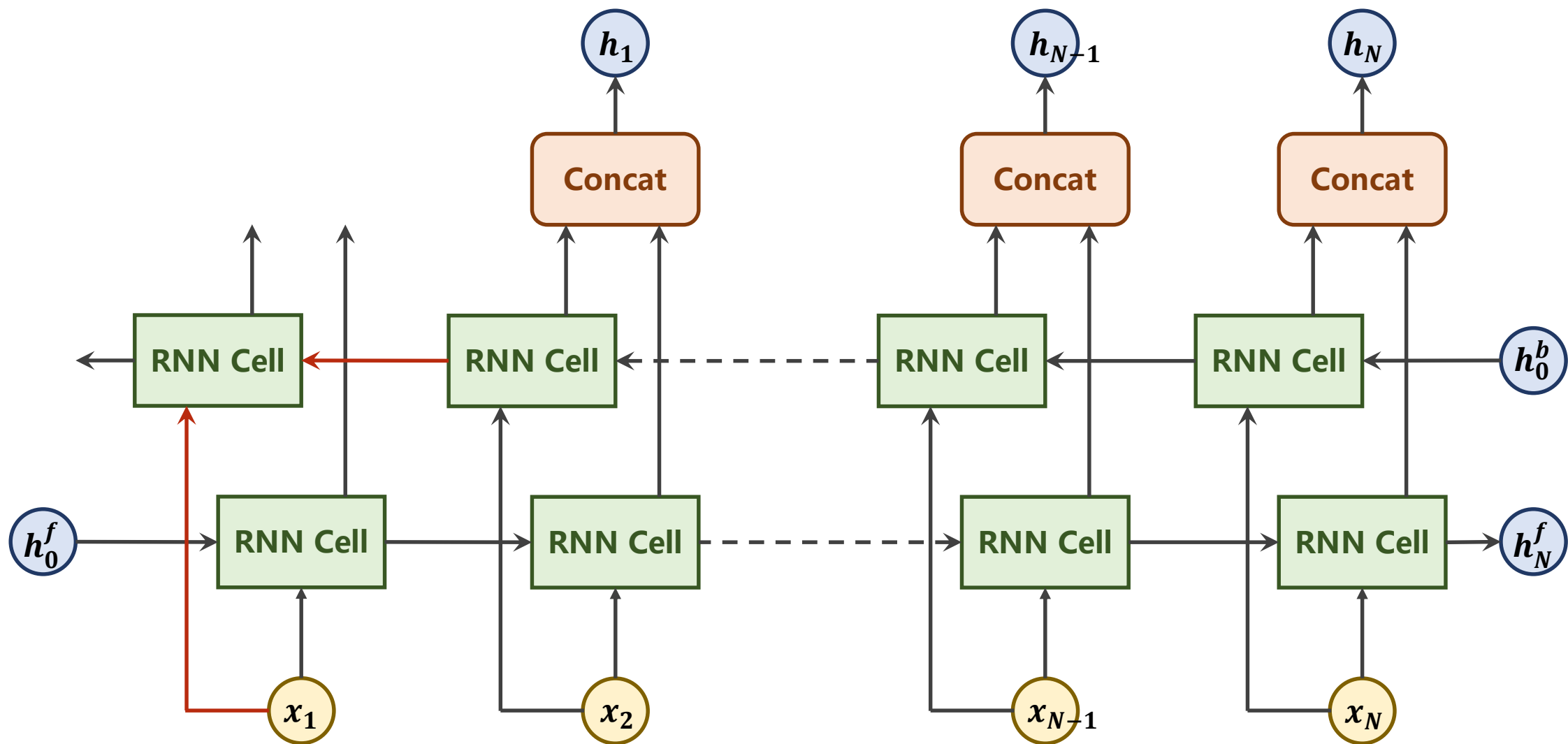
Implementation – Bi-direction RNN/LSTM/GRU



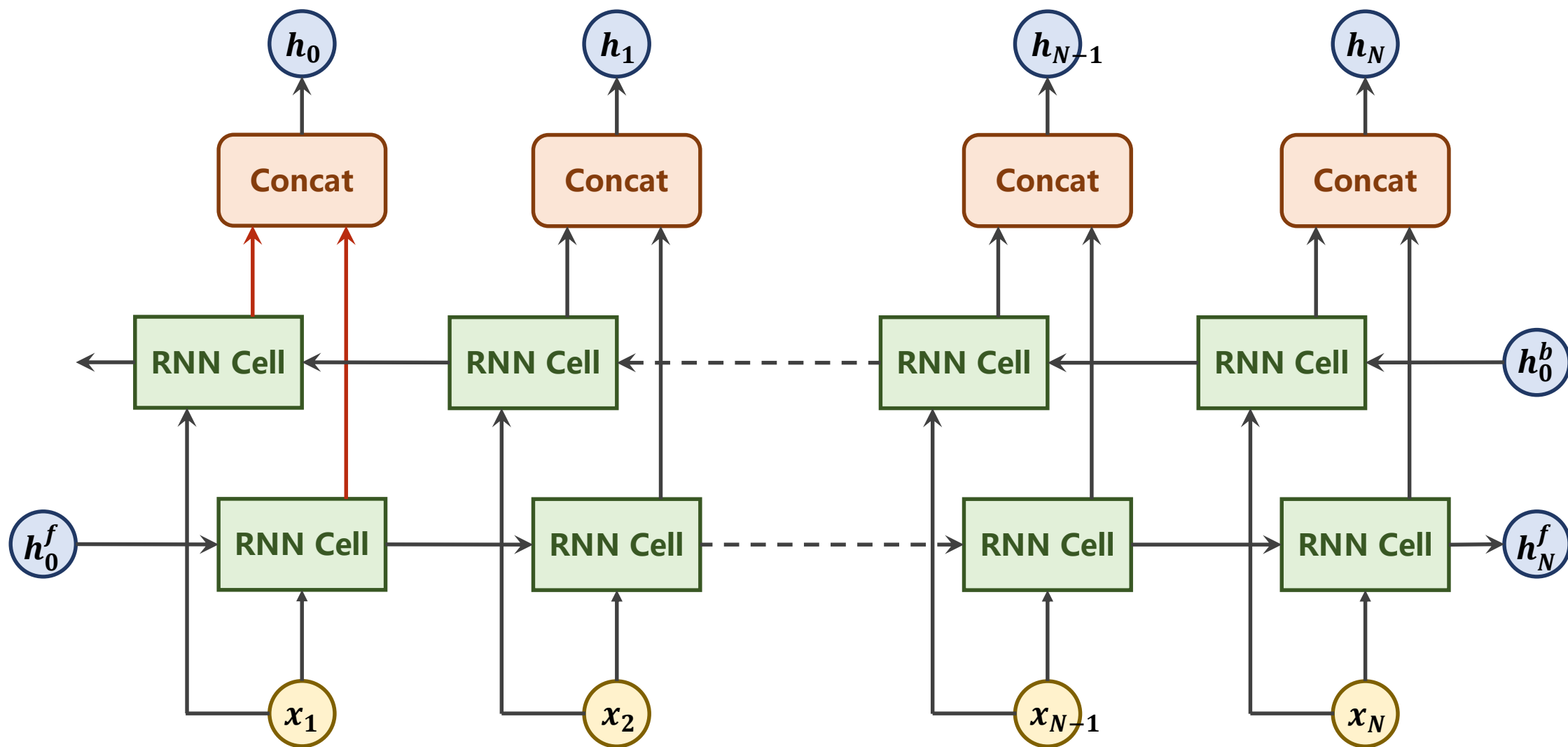
Implementation – Bi-direction RNN/LSTM/GRU



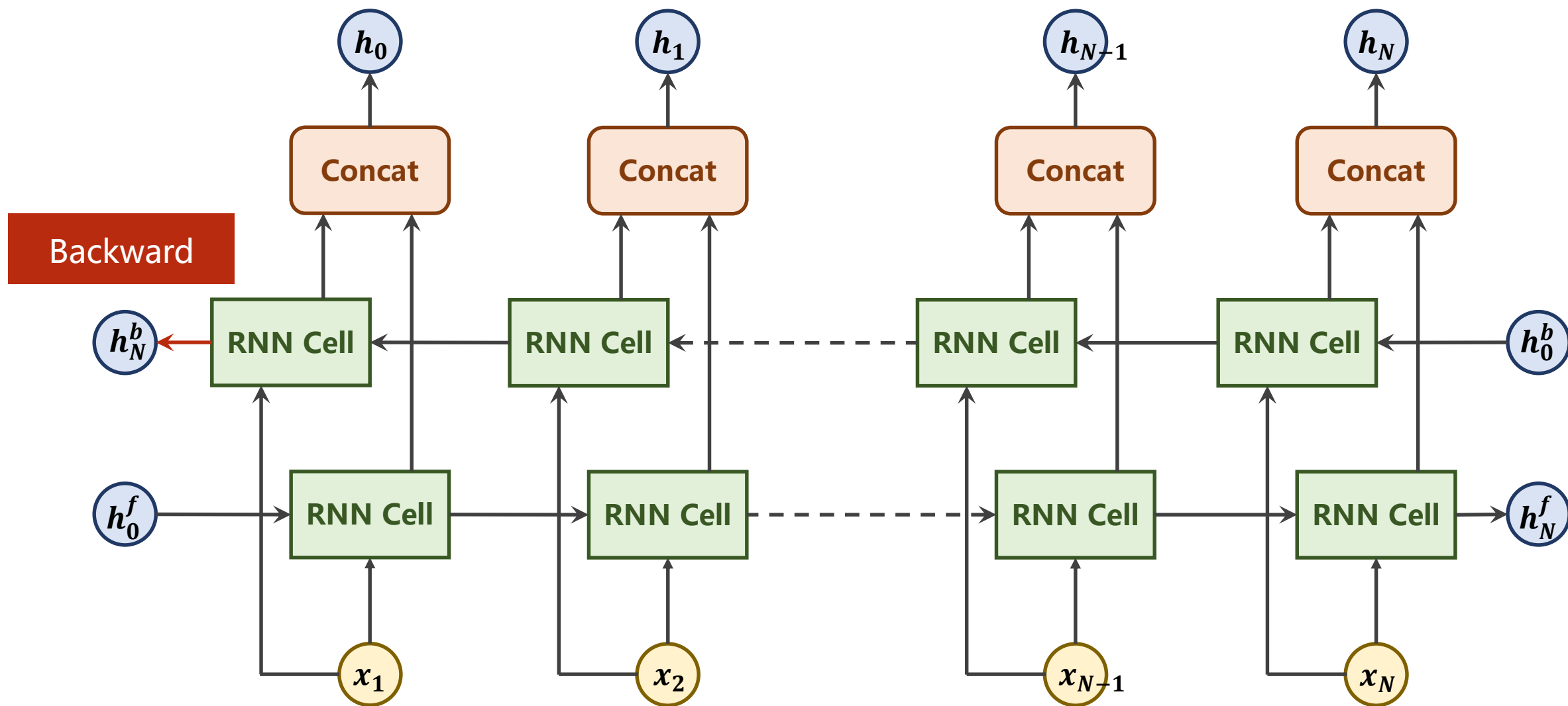
Implementation – Bi-direction RNN/LSTM/GRU



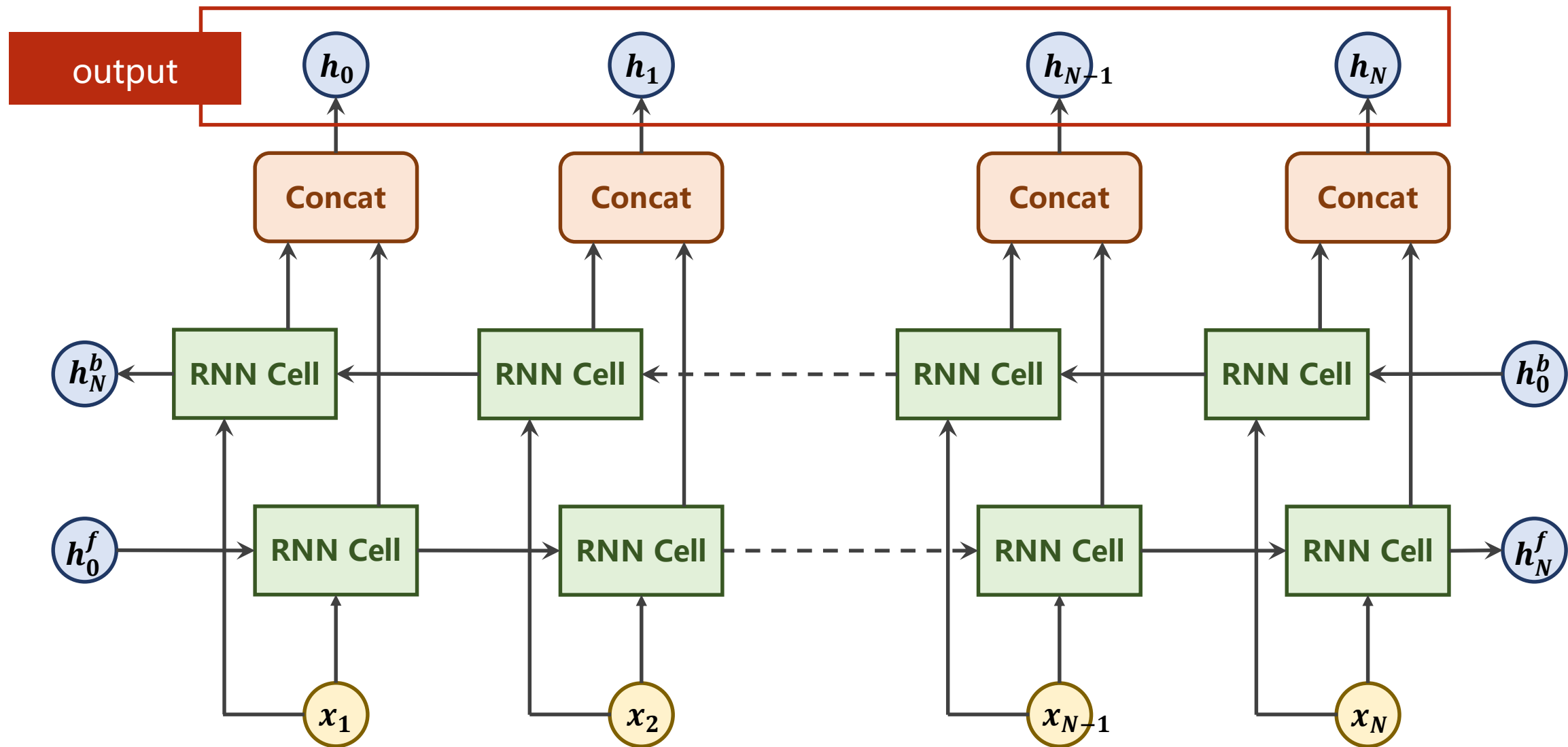
Implementation – Bi-direction RNN/LSTM/GRU



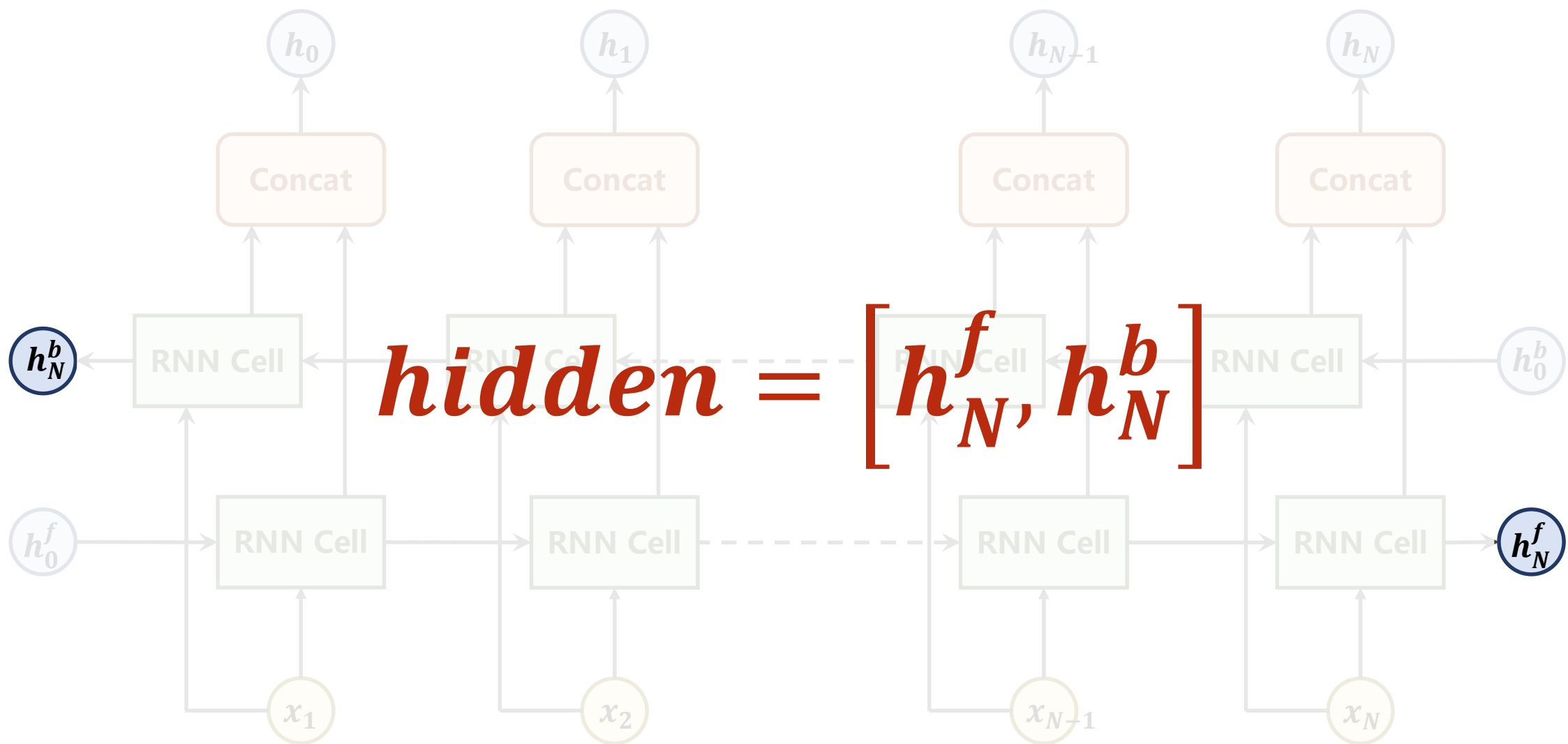
Implementation – Bi-direction RNN/LSTM/GRU



Implementation – Bi-direction RNN/LSTM/GRU



Implementation – Bi-direction RNN/LSTM/GRU



Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, n_layers, n_directions, output_size,
                 embedding_dim, gru_hidden_dim, gru_dropout,
                 bidirectional):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.n_layers = n_layers
        self.n_directions = 2 if bidirectional else 1

        self.embedding = torch.nn.Embedding(input_size, embedding_dim)
        self.gru = torch.nn.GRU(gru_hidden_dim, hidden_size, n_layers,
                                dropout=gru_dropout,
                                bidirectional=bidirectional)
        self.fc = torch.nn.Linear(hidden_size * self.n_directions, output_size)

    def _init_hidden(self, batch_size):
        hidden = torch.zeros(self.n_layers * self.n_directions,
                              batch_size, self.hidden_size)
        return create_tensor(hidden)
```

The **inputs** of GRU Layer with shape:

input: (seqLen, batchSize, hiddenSize)

*hidden: (nLayers * nDirections, batchSize, hiddenSize)*

The **outputs** of GRU Layer with shape:

*output: (seqLen, batchSize, hiddenSize * nDirections)*

*hidden: (nLayers * nDirections, batchSize, hiddenSize)*

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def __init__(self, input_size, hidden_size, n_layers, n_directions=2, bidirectional=True, output_size):
        super(RNNClassifier, self).__init__()
        self.hidden_size = hidden_size
        self.n_layers = n_layers
        self.n_directions = n_directions
        self.bidirectional = bidirectional

        self.embedding = torch.nn.Embedding(input_size, hidden_size)
        self.gru = torch.nn.GRU(hidden_size, hidden_size, n_layers)

        self.fc = torch.nn.Linear(hidden_size * self.n_directions, output_size)

    def _init_hidden(self, batch_size):
        hidden = torch.zeros(self.n_layers * self.n_directions,
                              batch_size, self.hidden_size)
        return create_tensor(hidden)
```

The **inputs** of GRU Layer with shape:

input: (seqLen, batchSize, hiddenSize)

*hidden: (nLayers * nDirections, batchSize, hiddenSize)*

The **outputs** of GRU Layer with shape:

*output: (seqLen, batchSize, hiddenSize * nDirections)*

*hidden: (nLayers * **nDirections**, batchSize, **hiddenSize**)*

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)
```

After padding									
[77	97	99	108	101	97	110	0	0	0]
[86	97	106	110	105	99	104	121	0	0]
[78	97	115	105	107	111	118	115	107	121]
[85	115	97	109	105	0	0	0	0	0]
[70	105	111	110	105	110	0	0	0	0]
[83	104	97	114	107	101	121	0	0	0]
[66	97	108	97	103	117	108	0	0	0]
[80	97	107	104	114	105	110	0	0	0]
[84	97	110	115	104	111	0	0	0	0]

(batchSize, seqLen)



After transpose								
77	86	78	85	70	83	66	80	84
97	97	97	115	105	104	97	97	97
99	106	115	97	111	97	108	107	110
108	110	105	109	110	114	97	104	115
101	105	107	105	105	107	103	114	104
97	99	111	0	110	101	117	105	111
110	104	118	0	0	121	108	110	0
0	101	115	0	0	0	0	0	0
0	0	107	0	0	0	0	0	0
0	0	121	0	0	0	0	0	0

(seqLen, batchSize)

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Save batch-size for make initial *hidden*.

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S
        input = input.t()
        batch_size = input.size(0)
        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Initial hidden with shape:
(*nLayer * nDirections, batchSize, hiddenSize*)

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S x V
        input = input.t()
        batch_size = input.size(0)

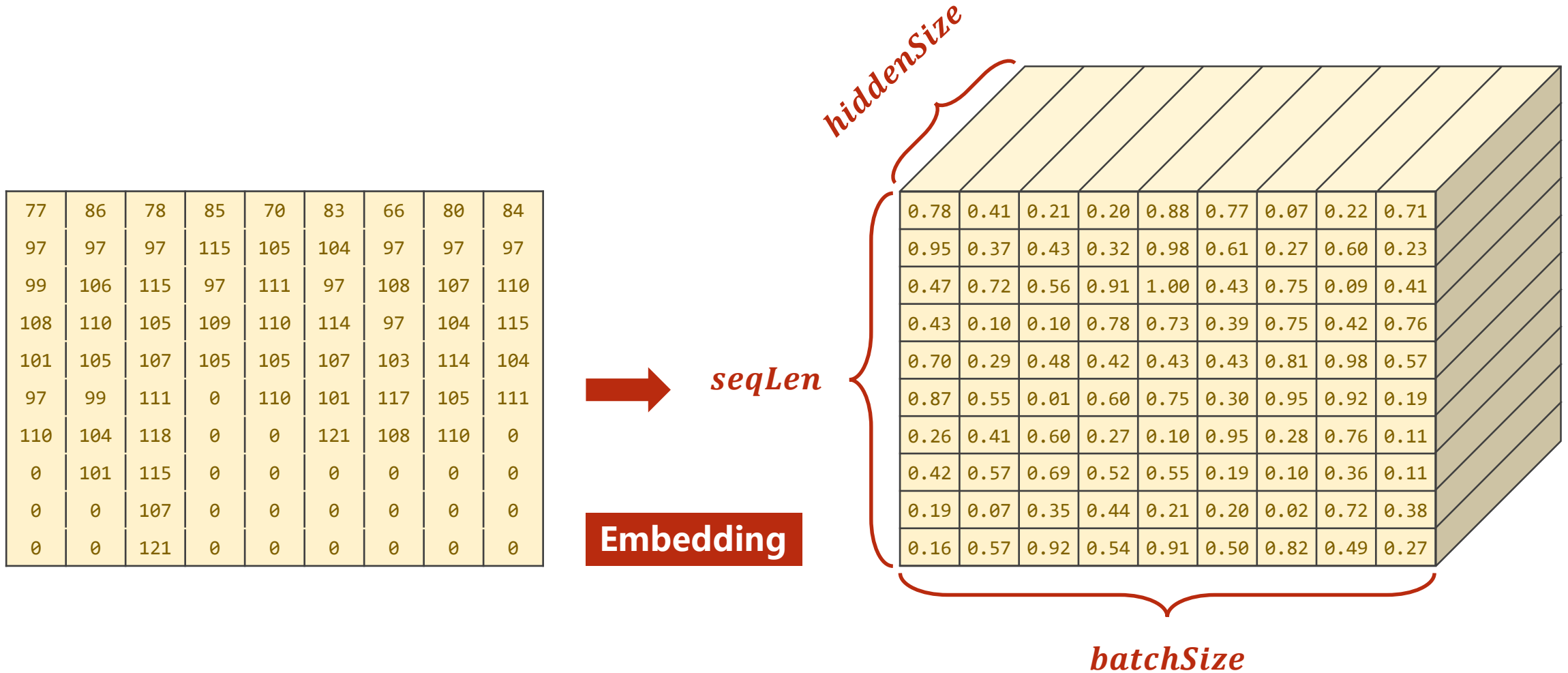
        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

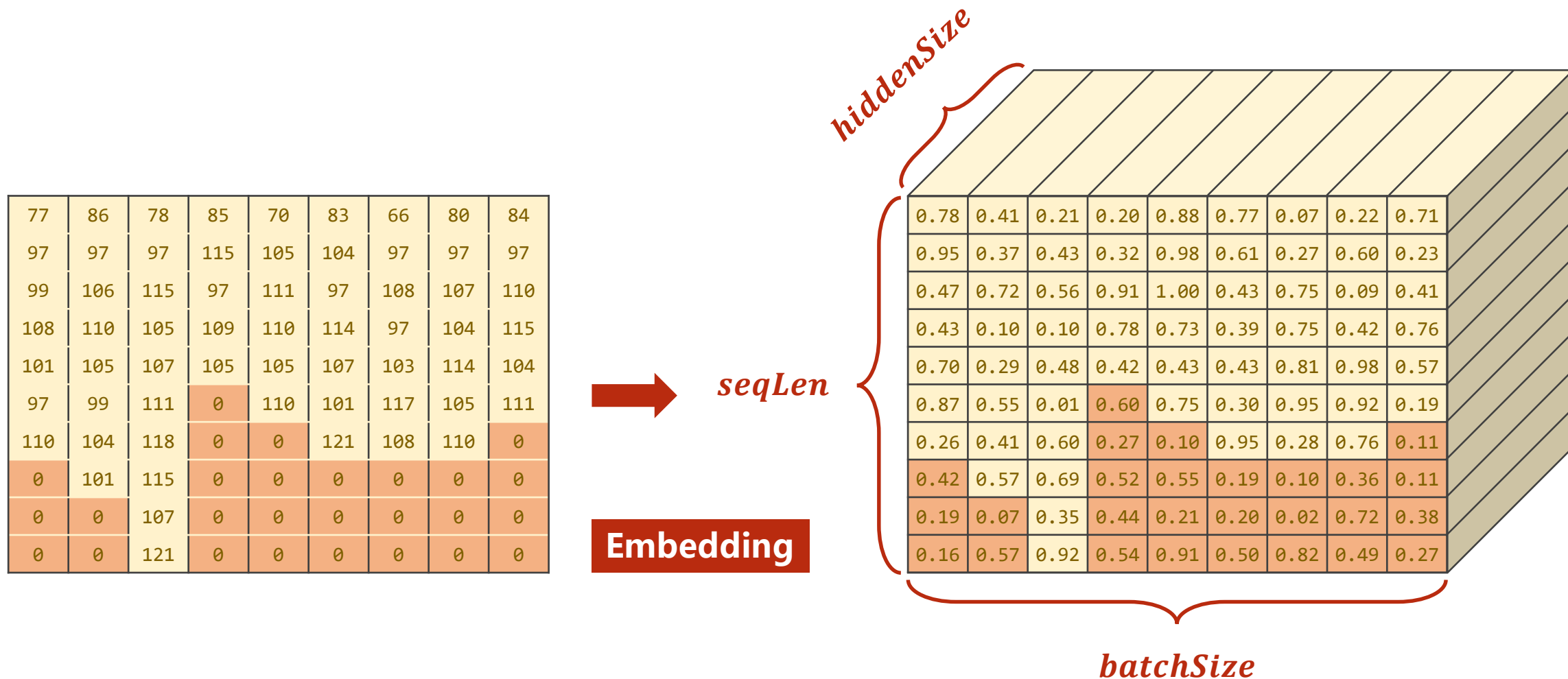
        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Result of embedding with shape:
(seqLen, batchSize, hiddenSize)

Implementation – Model Design



Implementation – Model Design



Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):  
    def forward(self, input, seqLen, batchSize, hiddenSize):  
        # input shape : B x seqLen x hiddenSize  
        input = input.t()  
        batch_size = input.size(0)
```

The first parameter with shape:

$(seqLen, batchSize, hiddenSize)$

The second parameter is a tensor, which is a list of sequence length of each batch element.

```
        hidden = self._init_hidden(batch_size)  
        embedding = self.embedding(input)  
  
        # pack them up  
        gru_input = pack_padded_sequence(embedding, seq_lengths, batch_first=True)  
  
        output, hidden = self.gru(gru_input, hidden)  
        if self.n_directions == 2:  
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)  
        else:  
            hidden_cat = hidden[-1]  
        fc_output = self.fc(hidden_cat)  
        return fc_output
```

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hid
        embedding = self.embedding

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Result of embedding with shape:
(seqLen, batchSize, hiddenSize)

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x seqLen x batchSize x hiddenSize
        input = input.t()
        batch_size = input.size(0)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

The first parameter with shape:

$(seqLen, batchSize, hiddenSize)$

The second parameter is a tensor, which is a list of sequence length of each batch element.

It returns a **PackedSequence** object.

Implementation – Model Design

```
torch.nn.utils.rnn.PackedSequence(cls, *args) \[source\]
```

Holds the data and list of `batch_sizes` of a packed sequence.

All RNN modules accept packed sequences as inputs.

! Note

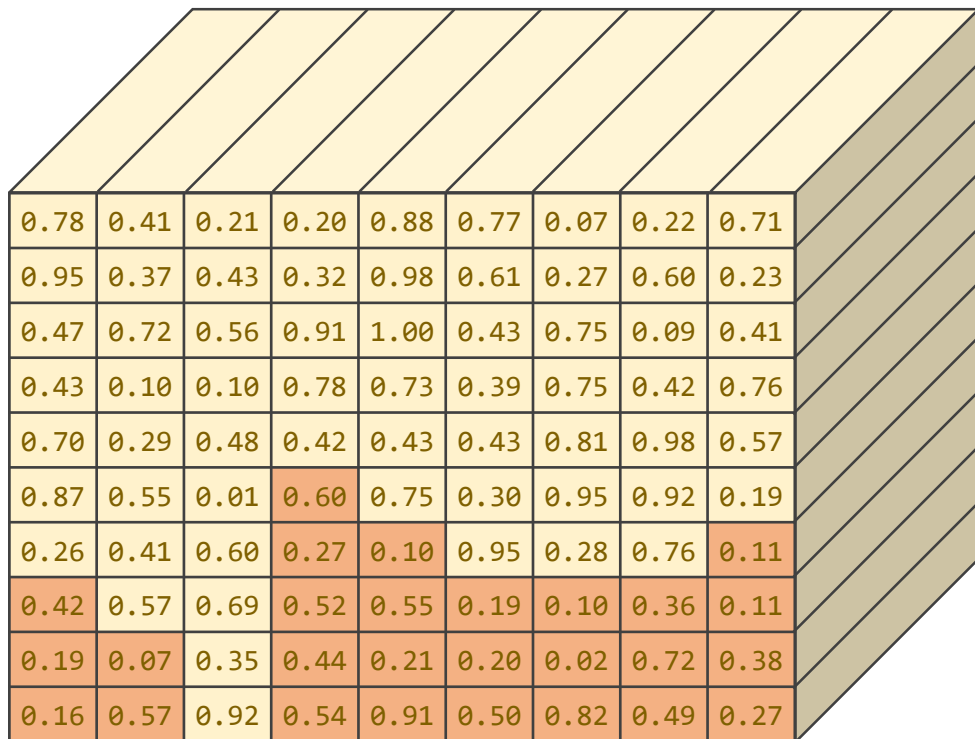
Instances of this class should never be created manually. They are meant to be instantiated by functions like `pack_padded_sequence()`.

Batch sizes represent the number elements at each sequence step in the batch, not the varying sequence lengths passed to `pack_padded_sequence()`. For instance, given data `abc` and `x` the `PackedSequence` would contain data `axbc` with `batch_sizes=[2,1,1]`.

Variables:

- `data` (*Tensor*) – Tensor containing packed sequence
- `batch_sizes` (*Tensor*) – Tensor of integers holding information about the batch size at each sequence step

Implementation – Model Design



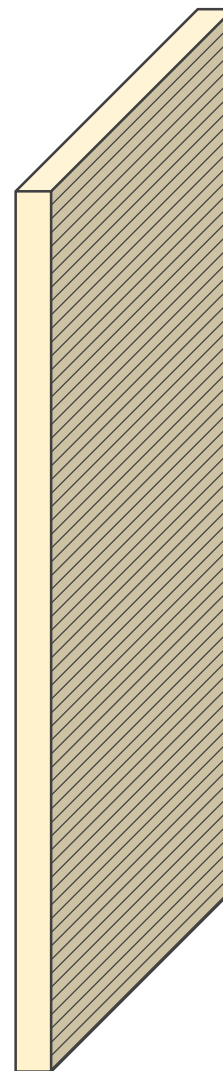
0.78	0.41	0.21	0.20	0.88	0.77	0.07	0.22	0.71
0.95	0.37	0.43	0.32	0.98	0.61	0.27	0.60	0.23
0.47	0.72	0.56	0.91	1.00	0.43	0.75	0.09	0.41
0.43	0.10	0.10	0.78	0.73	0.39	0.75	0.42	0.76
0.70	0.29	0.48	0.42	0.43	0.43	0.81	0.98	0.57
0.87	0.55	0.01	0.60	0.75	0.30	0.95	0.92	0.19
0.26	0.41	0.60	0.27	0.10	0.95	0.28	0.76	0.11
0.42	0.57	0.69	0.52	0.55	0.19	0.10	0.36	0.11
0.19	0.07	0.35	0.44	0.21	0.20	0.02	0.72	0.38
0.16	0.57	0.92	0.54	0.91	0.50	0.82	0.49	0.27

7	8	10	5	6	7	7	7	6
---	---	----	---	---	---	---	---	---

Must be sorted by descendent



It cannot work!



Implementation – Model Design

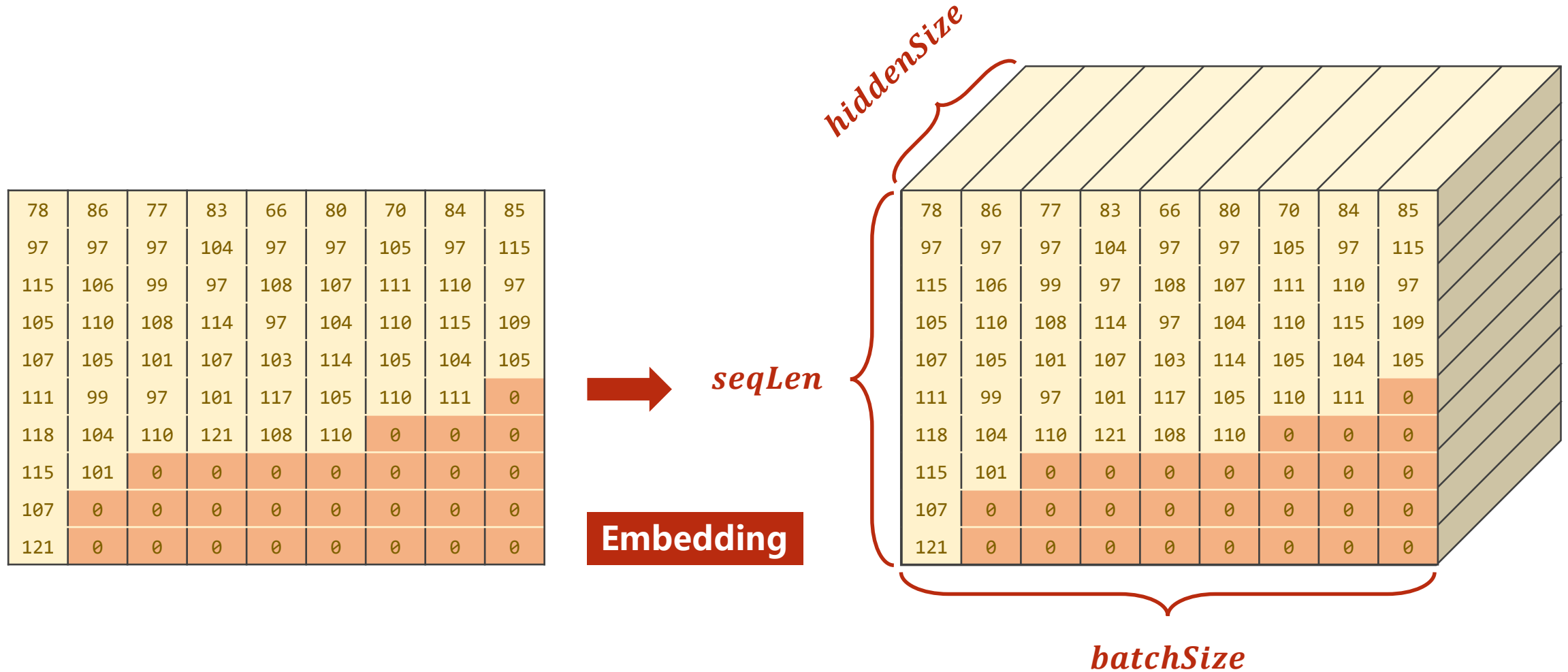
77	86	78	85	70	83	66	80	84
97	97	97	115	105	104	97	97	97
99	106	115	97	111	97	108	107	110
108	110	105	109	110	114	97	104	115
101	105	107	105	105	107	103	114	104
97	99	111	0	110	101	117	105	111
110	104	118	0	0	121	108	110	0
0	101	115	0	0	0	0	0	0
0	0	107	0	0	0	0	0	0
0	0	121	0	0	0	0	0	0



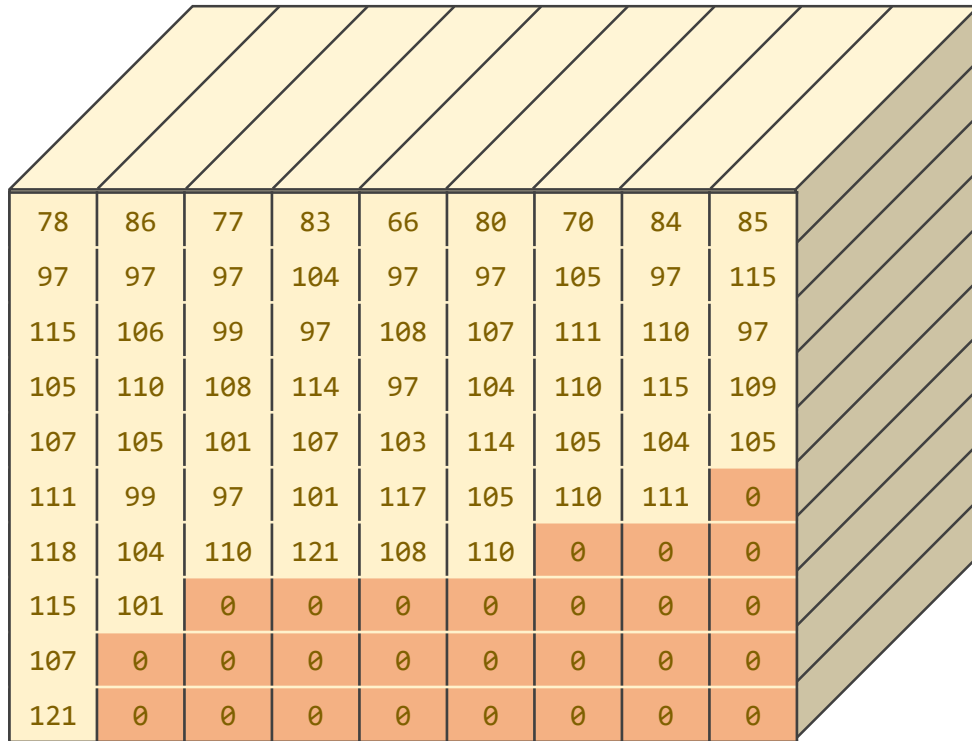
78	86	77	83	66	80	70	84	85
97	97	97	104	97	97	105	97	115
115	106	99	97	108	107	111	110	97
105	110	108	114	97	104	110	115	109
107	105	101	107	103	114	105	104	105
111	99	97	101	117	105	110	111	0
118	104	110	121	108	110	0	0	0
115	101	0	0	0	0	0	0	0
107	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0

We have to sort the batch element by length of sequence.

Implementation – Model Design



Implementation – Model Design

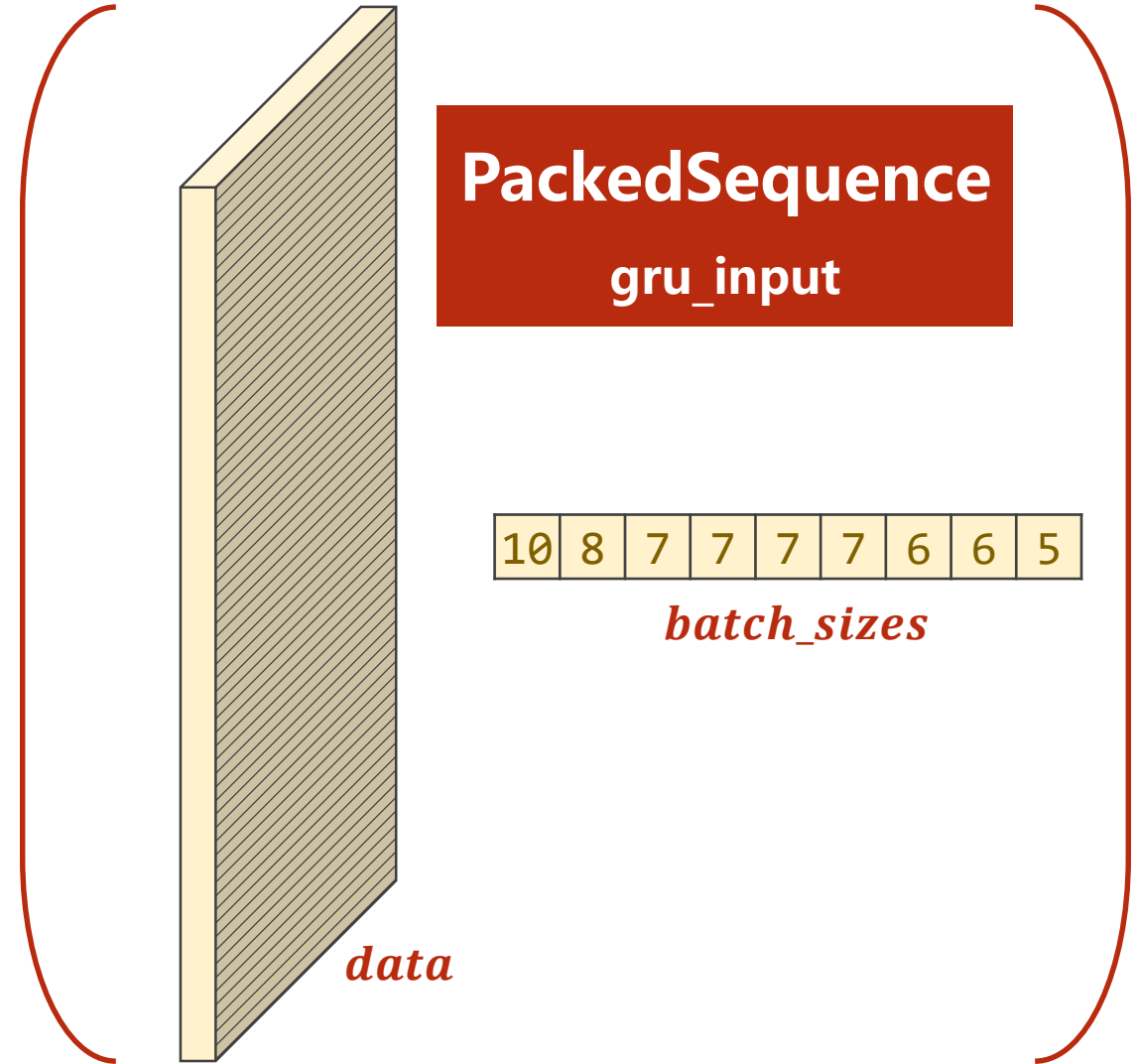


78	86	77	83	66	80	70	84	85
97	97	97	104	97	97	105	97	115
115	106	99	97	108	107	111	110	97
105	110	108	114	97	104	110	115	109
107	105	101	107	103	114	105	104	105
111	99	97	101	117	105	110	111	0
118	104	110	121	108	110	0	0	0
115	101	0	0	0	0	0	0	0
107	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0

embedding

10	8	7	7	7	7	6	6	5
----	---	---	---	---	---	---	---	---

seq_length



Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):  
    def forward(self, input, seqLens):  
        # input shape : B x seqLen x hiddenSize  
        input = input.t()  
        batch_size = input.size(0)
```

```
        hidden = self._init_hidden(batch_size)  
        embedding = self.embedding
```

```
        # pack them up
```

```
        gru_input = pack_padded_sequence(embedding, seq_lengths, batch_first=True)
```

```
        output, hidden = self.gru(gru_input, hidden)
```

```
        if self.n_directions == 2:
```

```
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
```

```
        else:
```

```
            hidden_cat = hidden[-1]
```

```
        fc_output = self.fc(hidden_cat)
```

```
        return fc_output
```

The first parameter with shape:

$(seqLen, batchSize, hiddenSize)$

The second parameter is a tensor, which is a list of sequence length of each batch element.

It returns a **PackedSequence** object.

Implementation – Model Design

```
class RNNClassifier
```

```
    def forward
```

```
        # input
```

```
        input =
```

```
        batch_s
```

```
        hidden = self._init_hidden(batch_size)
```

```
        embedding = self.embedding(input)
```

```
        # pack them up
```

```
        gru_input = pack_padded_sequence(embedding, seq_lengths)
```

```
        output, hidden = self.gru(gru_input, hidden)
```

```
        if self.n_directions == 2:
```

```
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
```

```
        else:
```

```
            hidden_cat = hidden[-1]
```

```
        fc_output = self.fc(hidden_cat)
```

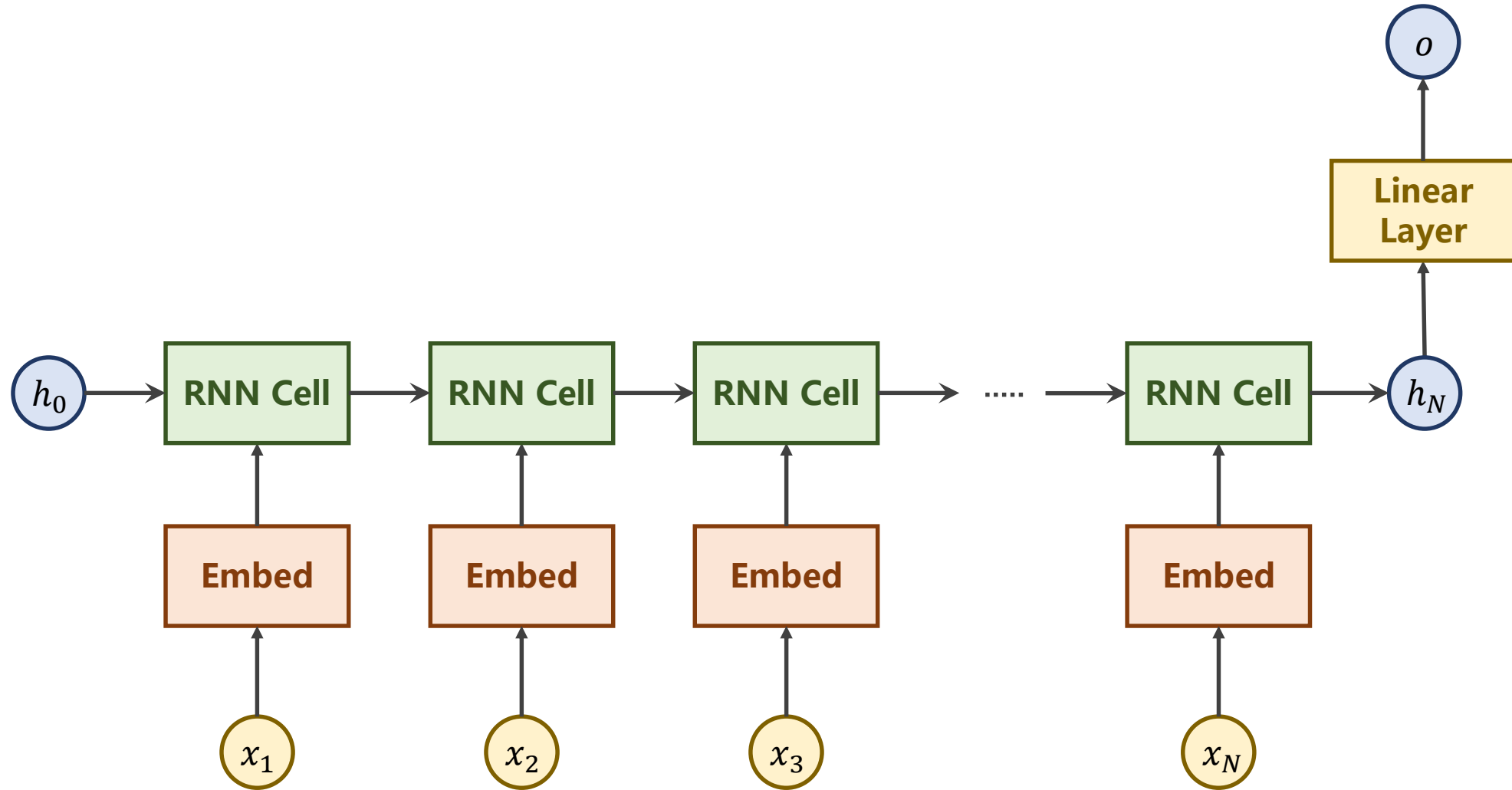
```
        return fc_output
```

The output is a PackedSequence object, actually it is a tuple.

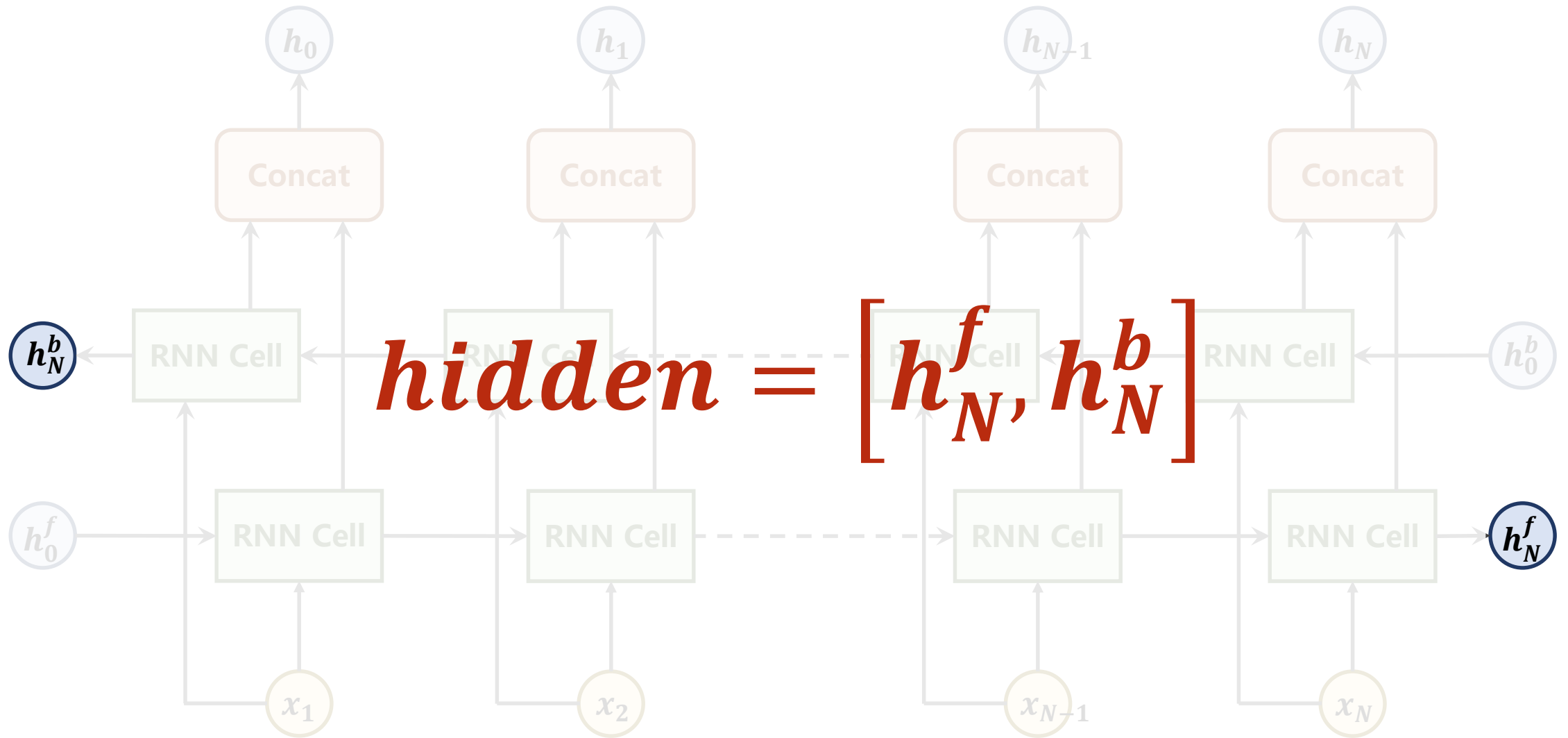
the shape of **hidden**, which we concerned, with shape:

$(nLayers * nDirection, batchSize, hiddenSize)$

Implementation – Model Design



Implementation – Model Design



Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)
```

```
        # pack
        gru_inp
```

If we use bidirectional GRU, the forward hidden and backward hidden should be concatenate.

```
        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```


Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Use linear classifier.

Implementation – Model Design

```
class RNNClassifier(torch.nn.Module):
    def forward(self, input, seq_lengths):
        # input shape : B x S -> S x B
        input = input.t()
        batch_size = input.size(1)

        hidden = self._init_hidden(batch_size)
        embedding = self.embedding(input)

        # pack them up
        gru_input = pack_padded_sequence(embedding, seq_lengths)

        output, hidden = self.gru(gru_input, hidden)
        if self.n_directions == 2:
            hidden_cat = torch.cat([hidden[-1], hidden[-2]], dim=1)
        else:
            hidden_cat = hidden[-1]
        fc_output = self.fc(hidden_cat)
        return fc_output
```

Implementation – Convert name to tensor

Name
Maclean
Vajnichy
Nasikovsky
Usami
Fionin
Sharkey
Balagul
Pakhrin
Tansho



78	86	77	83	66	80	70	84	85
97	97	97	104	97	97	105	97	115
115	106	99	97	108	107	111	110	97
105	110	108	114	97	104	110	115	109
107	105	101	107	103	114	105	104	105
111	99	97	101	117	105	110	111	0
118	104	110	121	108	110	0	0	0
115	101	0	0	0	0	0	0	0
107	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0

10	8	7	7	7	7	6	6	5
----	---	---	---	---	---	---	---	---

Implementation – Convert name to tensor

Name	Characters	ASCII
Maclean	['M', 'a', 'c', 'l', 'e', 'a', 'n']	[77 97 99 108 101 97 110]
Vajnichy	['V', 'a', 'j', 'n', 'i', 'c', 'h', 'y']	[86 97 106 110 105 99 104 121]
Nasikovsky	['N', 'a', 's', 'i', 'k', 'o', 'v', 's', 'k', 'y']	[78 97 115 105 107 111 118 115 107 121]
Usami	['U', 's', 'a', 'm', 'i']	[85 115 97 109 105]
Fionin	['F', 'i', 'o', 'n', 'i', 'n']	[70 105 111 110 105 110]
Sharkey	['S', 'h', 'a', 'r', 'k', 'e', 'y']	[83 104 97 114 107 101 121]
Balagul	['B', 'a', 'l', 'a', 'g', 'u', 'l']	[66 97 108 97 103 117 108]
Pakhrin	['P', 'a', 'k', 'h', 'r', 'i', 'n']	[80 97 107 104 114 105 110]
Tansho	['T', 'a', 'n', 's', 'h', 'o']	[84 97 110 115 104 111]

Implementation – Convert name to tensor

ASCII
[77 97 99 108 101 97 110]
[86 97 106 110 105 99 104 121]
[78 97 115 105 107 111 118 115 107 121]
[85 115 97 109 105]
[70 105 111 110 105 110]
[83 104 97 114 107 101 121]
[66 97 108 97 103 117 108]
[80 97 107 104 114 105 110]
[84 97 110 115 104 111]



After padding
[77 97 99 108 101 97 110 0 0 0]
[86 97 106 110 105 99 104 121 0 0]
[78 97 115 105 107 111 118 115 107 121]
[85 115 97 109 105 0 0 0 0 0]
[70 105 111 110 105 110 0 0 0 0]
[83 104 97 114 107 101 121 0 0 0]
[66 97 108 97 103 117 108 0 0 0]
[80 97 107 104 114 105 110 0 0 0]
[84 97 110 115 104 111 0 0 0 0]

Implementation – Convert name to tensor

After padding									
[	77	97	99	108	101	97	110	0	0]
[	86	97	106	110	105	99	104	121	0]
[	78	97	115	105	107	111	118	115	107]
[	85	115	97	109	105	0	0	0	0]
[	70	105	111	110	105	110	0	0	0]
[	83	104	97	114	107	101	121	0	0]
[	66	97	108	97	103	117	108	0	0]
[	80	97	107	104	114	105	110	0	0]
[	84	97	110	115	104	111	0	0	0]

(batchSize, seqLen)



After transpose								
77	86	78	85	70	83	66	80	84
97	97	97	115	105	104	97	97	97
99	106	115	97	111	97	108	107	110
108	110	105	109	110	114	97	104	115
101	105	107	105	105	107	103	114	104
97	99	111	0	110	101	117	105	111
110	104	118	0	0	121	108	110	0
0	101	115	0	0	0	0	0	0
0	0	107	0	0	0	0	0	0
0	0	121	0	0	0	0	0	0

(seqLen, batchSize)

Implementation – Convert name to tensor

77	86	78	85	70	83	66	80	84
97	97	97	115	105	104	97	97	97
99	106	115	97	111	97	108	107	110
108	110	105	109	110	114	97	104	115
101	105	107	105	105	107	103	114	104
97	99	111	0	110	101	117	105	111
110	104	118	0	0	121	108	110	0
0	101	115	0	0	0	0	0	0
0	0	107	0	0	0	0	0	0
0	0	121	0	0	0	0	0	0



78	86	77	83	66	80	70	84	85
97	97	97	104	97	97	105	97	115
115	106	99	97	108	107	111	110	97
105	110	108	114	97	104	110	115	109
107	105	101	107	103	114	105	104	105
111	99	97	101	117	105	110	111	0
118	104	110	121	108	110	0	0	0
115	101	0	0	0	0	0	0	0
107	0	0	0	0	0	0	0	0
121	0	0	0	0	0	0	0	0

We have to sort the batch element by length of sequence.

Implementation – Convert name to tensor

```
def make_tensors(names, countries):
    sequences_and_lengths = [name2list(name) for name in names]
    name_sequences = [sl[0] for s in sequences_and_lengths]
    seq_lengths = torch.LongTensor([s[1] for s in sequences_and_lengths])
    countries = countries.long()

    # make tensor of name, BatchSize x seqLen
    seq_tensor = torch.zeros(len(name_sequences), seq_lengths.max()).long()
    for idx, (seq, seq_len) in enumerate(zip(name_sequences, seq_lengths), 0):
        seq_tensor[idx, :seq_len] = torch.LongTensor(seq)

    # sort by length to use pack_padded_sequence
    seq_lengths, perm_idx = seq_lengths.sort(dim=0, descending=True)
    seq_tensor = seq_tensor[perm_idx]
    countries = countries[perm_idx]

    return create_tensor(seq_tensor), \
           create_tensor(seq_lengths), \
           create_tensor(countries)
```

```
def name2list(name):
    arr = [ord(c) for c in name]
    return arr, len(arr)
```


Implementation – Convert name to tensor

```
def make_tensors(names, countries):  
    sequences_and_lengths = [name2list(name) for name in names]  
    name_sequences = [s1[0] for s1 in sequences_and_lengths]  
    seq_lengths = torch.LongTensor([s1[1] for s1 in sequences_and_lengths])  
    countries = countries.long()
```

```
# make tensor of name, BatchSize
```

```
seq_tensor = torch.zeros(len(names), seq_max_len)  
for idx, (seq, seq_len) in enumerate(sequences_and_lengths):  
    seq_tensor[idx, :seq_len] =
```

```
# sort by length to use pack_pad
```

```
seq_lengths, perm_idx = seq_lengths.sort(desc=True)  
seq_tensor = seq_tensor[perm_idx]  
countries = countries[perm_idx]
```

```
return create_tensor(seq_tensor)  
        create_tensor(seq_lengths)  
        create_tensor(countries)
```

ASCII

[77 97 99 108 101 97 110]

[86 97 106 110 105 99 104 121]

[78 97 115 105 107 111 118 115 107 121]

[85 115 97 109 105]

[70 105 111 110 105 110]

[83 104 97 114 107 101 121]

[66 97 108 97 103 117 108]

[80 97 107 104 114 105 110]

[84 97 110 115 104 111]

Implementation – Convert name to tensor

```
def make_tensors(names, countries):
    sequences_and_lengths = [name2list(name) for name in names]
    name_sequences = [sl[0] for sl in sequences_and_lengths]
    seq_lengths = torch.LongTensor([sl[1] for sl in sequences_and_lengths])
    countries = countries.long()

    # make tensor of name, BatchSize x SeqLen
    seq_tensor = torch.zeros(len(name_sequences), seq_lengths.max()).long()
    for idx, (seq, seq_len) in enumerate(zip(name_sequences, seq_lengths), 0):
        seq_tensor[idx, :seq_len] = torch.LongTensor(seq)

    # sort by length to use pack_padded_sequence
    seq_lengths, perm_idx = seq_lengths.sort(dim=0, descending=True)
    seq_tensor = seq_tensor[perm_idx]
    countries = countries[perm_idx]

    return create_tensor(seq_tensor), \
           create_tensor(seq_lengths), \
           create_tensor(countries)
```

Implementation – Convert name to tensor

```
def make_tensors(names, countries):  
    sequences_and_lengths = [name2list(name) for name in names]  
    name_sequences = [sl[0] for sl in sequences_and_lengths]  
    seq_lengths = torch.LongTensor([sl[1] for sl in sequences_and_lengths])  
    countries = countries.long()
```

```
# make tensor of name, BatchSize x SeqLen
```

```
seq_tensor = torch.zeros(len(name_sequences), seq_lengths.max()).long()  
for idx, (seq, seq_len) in enumerate(zip(name_sequences, seq_lengths), 0):  
    seq_tensor[idx, :seq_len] = torch.LongTensor(seq)
```

```
# sort by length to use pack_padded_sequence
```

```
seq_lengths, perm_idx = seq_lengths.sort(dim=0, descending=True)  
seq_tensor = seq_tensor[perm_idx]  
countries = countries[perm_idx]
```

```
return create_tensor(seq_tensor), \  
       create_tensor(seq_lengths), \  
       create_tensor(countries)
```

After padding									
[	77	97	99	108	101	97	110	0	0]
[	86	97	106	110	105	99	104	121	0]
[	78	97	115	105	107	111	118	115	107]
[	85	115	97	109	105	0	0	0	0]
[	70	105	111	110	105	110	0	0	0]
[	83	104	97	114	107	101	121	0	0]
[	66	97	108	97	103	117	108	0	0]
[	80	97	107	104	114	105	110	0	0]
[	84	97	110	115	104	111	0	0	0]

Implementation – Convert name to tensor

```
def make_tensors(names, countries):
    sequences_and_lengths = [name2list(name) for name in names]
    name_sequences = [sl[0] for sl in sequences_and_lengths]
    seq_lengths = torch.LongTensor([sl[1] for sl in sequences_and_lengths])
    countries = countries.long()

    # make tensor of name, BatchSize x SeqLen
    seq_tensor = torch.zeros(len(name_sequences), seq_lengths.max()).long()
    for idx, (seq, seq_len) in enumerate(zip(name_sequences, seq_lengths), 0):
        seq_tensor[idx, :seq_len] = torch.LongTensor(seq)

    # sort by length to use pack_padded_sequence
    seq_lengths, perm_idx = seq_lengths.sort(dim=0, descending=True)
    seq_tensor = seq_tensor[perm_idx]
    countries = countries[perm_idx]

    return create_tensor(seq_tensor), \
           create_tensor(seq_lengths), \
           create_tensor(countries)
```

Implementation – Convert name to tensor

After padding		After padding
[77 97 99 108 101 97 110 0 0 0]		[78 97 115 105 107 111 118 115 107 121]
[86 97 106 110 105 99 104 121 0 0]		[86 97 106 110 105 99 104 121 0 0]
[78 97 115 105 107 111 118 115 107 121]		[83 104 97 114 107 101 121 0 0 0]
[85 115 97 109 105 0 0 0 0 0]		[66 97 108 97 103 117 108 0 0 0]
[70 105 111 110 105 110 0 0 0 0]		[80 97 107 104 114 105 110 0 0 0]
[83 104 97 114 107 101 121 0 0 0]		[77 97 99 108 101 97 110 0 0 0]
[66 97 108 97 103 117 108 0 0 0]		[70 105 111 110 105 110 0 0 0 0]
[80 97 107 104 114 105 110 0 0 0]		[84 97 110 115 104 111 0 0 0 0]
[84 97 110 115 104 111 0 0 0 0]		[85 115 97 109 105 0 0 0 0 0]

```
# sort by length to use pack_padded_sequence
seq_lengths, perm_idx = seq_lengths.sort(dim=0, descending=True)
seq_tensor = seq_tensor[perm_idx]
countries = countries[perm_idx]
```

```
return create_tensor(seq_tensor), \
       create_tensor(seq_lengths), \
       create_tensor(countries)
```

Implementation – Convert name to tensor

```
def make_tensors(names, countries):
    sequences_and_lengths = [name2list(name) for name in names]
    name_sequences = [sl[0] for sl in sequences_and_lengths]
    seq_lengths = torch.LongTensor([sl[1] for sl in sequences_and_lengths])
    countries = countries.long()

    # make tensor of name, BatchSize x SeqLen
    seq_tensor = torch.zeros(len(name_sequences), seq_lengths.max()).long()
    for idx, (seq, seq_len) in enumerate(zip(name_sequences, seq_lengths), 0):
        seq_tensor[idx, :seq_len] = torch.LongTensor(seq)

    # sort by length to use pack_padded_sequence
    seq_lengths, perm_idx = seq_lengths.sort(dim=0, descending=True)
    seq_tensor = seq_tensor[perm_idx]
    countries = countries[perm_idx]

    return create_tensor(seq_tensor), \
           create_tensor(seq_lengths), \
           create_tensor(countries)
```

```
def create_tensor(tensor):
    if USE_GPU:
        device = torch.device("cuda:0")
        tensor = tensor.to(device)
    return tensor
```

Implementation – One Epoch Training

```
def trainModel():  
    total_loss = 0  
    for i, (names, countries) in enumerate(trainloader, 1):  
        inputs, seq_lengths, target = make_tensors(names, countries)  
        output = classifier(inputs, seq_lengths)  
        loss = criterion(output, target)  
        optimizer.zero_grad()  
        loss.backward()  
        optimizer.step()  
  
        total_loss += loss.item()  
        if i % 10 == 0:  
            print(f'[{time.strftime("%H:%M:%S")}] {i} * len(trainloader) = {total_loss}')  
            print(f'loss={total_loss}')  
    return total_loss
```

1. forward – compute output of model
2. forward – compute loss
3. zero grad
4. backward
5. update

Implementation – One Epoch Training

```
def trainModel():
    total_loss = 0
    for i, (names, countries) in enumerate(trainloader, 1):
        inputs, seq_lengths, target = make_tensors(names, countries)
        output = classifier(inputs, seq_lengths)
        loss = criterion(output, target)
        optimizer.zero_grad()
        loss.backward()
        optimizer.step()

        total_loss += loss.item()
        if i % 10 == 0:
            print(f'[{time_since(start)}] Epoch {epoch} ', end='')
            print(f'[{i * len(inputs)} / {len(trainset)}] ', end='')
            print(f'loss={total_loss / (i * len(inputs))}')
    return total_loss
```


Implementation – Testing

```
def testModel():
    correct = 0
    total = len(testset)
    print("evaluating trained model ...")
    with torch.no_grad():
        for i, (names, countries) in enumerate(testloader, 1):
            inputs, seq_lengths, target = make_tensors(names, countries)
            output = classifier(inputs, seq_lengths)
            pred = output.max(dim=1, keepdim=True)[1]
            correct += pred.eq(target.view_as(pred)).sum().item()

    percent = '%.2f' % (100 * correct / total)
    print(f'Test set: Accuracy {percent}%')

    return correct / total
```

Tell PyTorch not to compute gradient of computational graph.
Saving time and memory!

Implementation – Testing

```
def testModel():
    correct = 0
    total = len(testset)
    print("evaluating trained model ...")
    with torch.no_grad():
        for i, (names, countries) in enumerate(testloader, 1):
            inputs, seq_lengths, target = make_tensors(names, countries)
            output = classifier(inputs, seq_lengths)
            pred = output.max(dim=-1)
            correct += pred.eq(target).sum().item()

    percent = '%.2f' % (100 * correct / total)
    print(f'Test set: Accuracy {correct}/{total} {percent}%')

    return correct / total
```

Compute the output of the model.

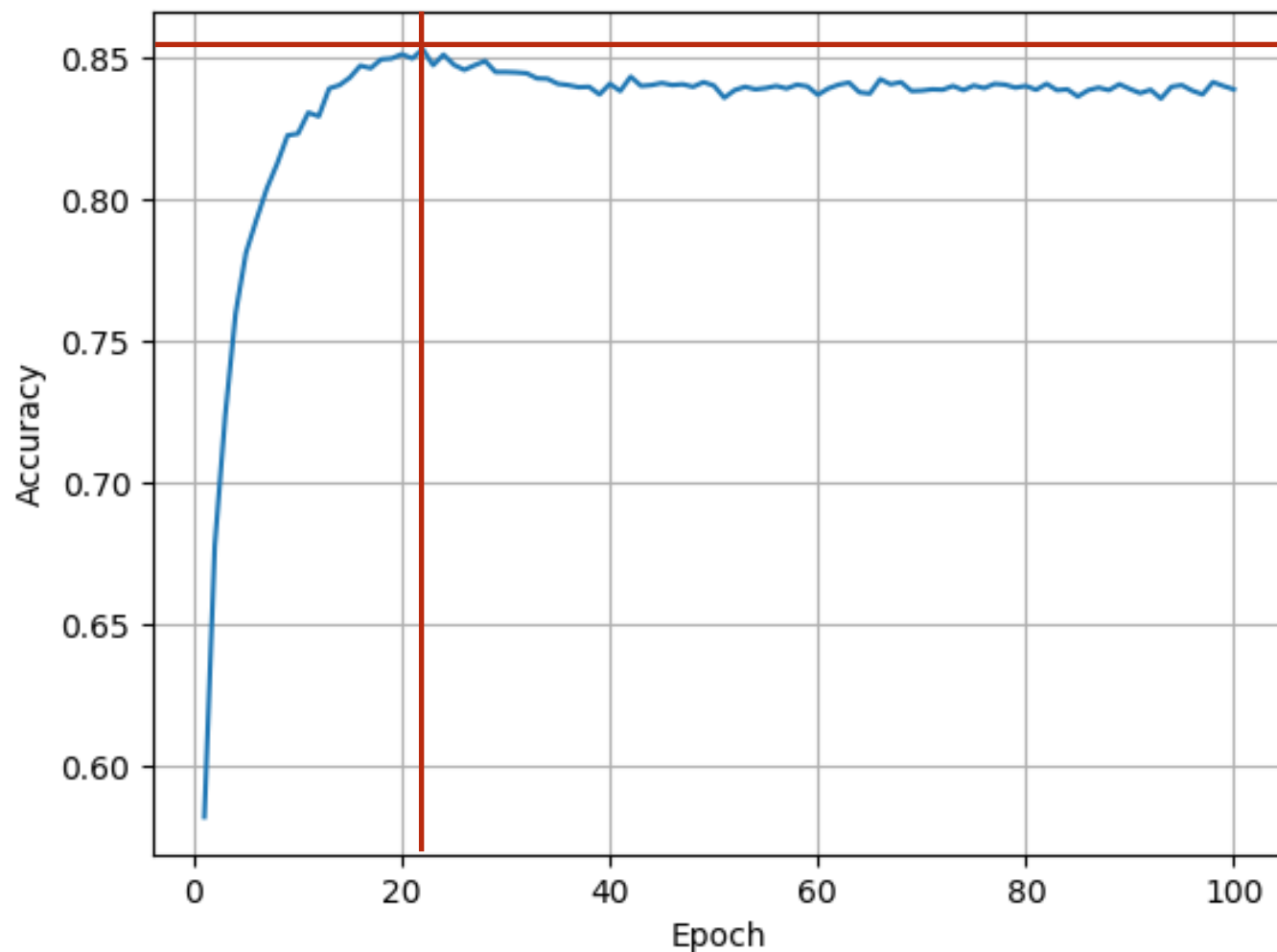
Implementation – Testing

```
def testModel():
    correct = 0
    total = len(testset)
    print("evaluating trained model ...")
    with torch.no_grad():
        for i, (names, countries) in enumerate(testloader, 1):
            inputs, seq_lengths, target = make_tensors(names, countries)
            output = classifier(inputs, seq_lengths)
            pred = output.max(dim=1, keepdim=True)[1]
            correct += pred.eq(target.view_as(pred)).sum().item()

    percent = '%.2f' % (100 * Compute number of predicted correctly.)
    print(f'Test set: Accuracy {correct}/{total} {percent}%')

    return correct / total
```

Implementation – Result



Exercise 13-1 Sentiment Analysis on Movie Reviews

- The Rotten Tomatoes movie review dataset is a corpus of movie reviews used for sentiment analysis.
 - dataset: <https://www.kaggle.com/c/sentiment-analysis-on-movie-reviews/data>
 - The dataset is comprised of tab-separated files with phrases from the Rotten Tomatoes dataset.
- The sentiment labels are:
 - 0 - negative
 - 1 - somewhat negative
 - 2 - neutral
 - 3 - somewhat positive
 - 4 - positive

Exercise 13-1 Sentiment Analysis on Movie Reviews

The screenshot shows a web interface for a data platform. At the top, there are navigation tabs: Overview, Data (selected), Discussion, Leaderboard, Rules, and Team. On the right, there are links for My Submissions and a highlighted Late Submission button. Below the navigation, the 'Data' section is active, showing a list of data sources on the left, a description area in the middle, and a list of columns on the right. The data sources list includes 'sampleSubmission....', 'test.tsv', and 'train.tsv'. The 'test.tsv' and 'train.tsv' entries are highlighted with a red box. The 'About this file' section contains the text 'Help us describe this file'. The 'Columns' section lists: # Phraseld, # Sentenceld, A Phrase, and # Sentiment.

Overview	Data	Discussion	Leaderboard	Rules	Team	My Submissions	Late Submission
Data							
<div>API ? Download All</div>							
Data Sources		About this file		Columns			
<div>sampleSubmission.... 66.3k x 2</div> <div>test.tsv 66.3k x 3</div> <div>train.tsv 156k x 4</div>		<div>Help us describe this file</div>		<div># Phraseld</div> <div># Sentenceld</div> <div>A Phrase</div> <div># Sentiment</div>			

Exercise 13-1 Sentiment Analysis on Movie Reviews

Phraseld	Sentenceld	Phrase	Sentiment
1	1	A series of escapades demonstrating the adage that what is good for the goose is also good for the gander , some of which occasionally amuses but none of which amounts to much of a story .	1
2	1	A series of escapades demonstrating the adage that what is good for the goose	2
3	1	A series	2
4	1	A	2
5	1	series	2
6	1	of escapades demonstrating the adage that what is good for the goose	2
7	1	of	2
8	1	escapades demonstrating the adage that what is good for the goose	2
9	1	escapades	2
10	1	demonstrating the adage that what is good for the goose	2



PyTorch Tutorial

13. RNN Classifier