机器翻译和数据集

机器翻译（MT）：将一段文本从一种语言自动翻译为另一种语言，用神经网络解决这个问题通常称为神经机器翻译（NMT）。

主要特征：输出是单词序列而不是单个单词。 输出序列的长度可能与源序列的长度不同。

In [1]:

```
import os
os.listdir('/home/kesci/input/')
```

Out[1]:

```
['d2l4368', '.tmp',
```

In [2]:

```
import sys
sys.path.append('/home/kesci/input/d2l4368/')
import collections
import d2l.d2l
import zipfile
from d2l.d2l.data.base import Vocab
import time
import torch
import torch.nn as nn
import torch.nn.functional as F
from torch.utils import data
from torch import optim
```

数据预处理

将数据集清洗、转化为神经网络的输入minbatch

In [3]:

```
with open('/home/kesci/input/fraeng3068/fra-eng/fra.txt', 'r') as f:
      raw_text = f.read()
print(raw_text[0:1000])
```

```
Go.	Va !	CC-BY 2.0 (France) Attribution: tatoeba.org #2877272 (CM) & #1158250 (Wittydev)
Hi.	Salut !	CC-BY 2.0 (France) Attribution: tatoeba.org #538123 (CM) & #509819 (Aiji)
Hi.	Salut.	CC-BY 2.0 (France) Attribution: tatoeba.org #538123 (CM) & #4320462 (gillux)
Run!	Cours !	CC-BY 2.0 (France) Attribution: tatoeba.org #906328 (papabear) & #906331 (sacredceltic)
Run!	Courez !	CC-BY 2.0 (France) Attribution: tatoeba.org #906328 (papabear) & #906332 (sacredceltic)
Who?	Qui ?	CC-BY 2.0 (France) Attribution: tatoeba.org #2083030 (CK) & #4366796 (gillux)
Wow!	Ça alors !	CC-BY 2.0 (France) Attribution: tatoeba.org #52027 (Zifre) & #374631 (zmoo)
Fire!	Au feu !	CC-BY 2.0 (France) Attribution: tatoeba.org #1829639 (Spamster) & #4627939 (sacredcelt
Help!	À l'aide !	CC-BY 2.0 (France) Attribution: tatoeba.org #435084 (lukaszpp) & #128430 (sysko)
Jump.	Saute.	CC-BY 2.0 (France) Attribution: tatoeba.org #631038 (Shishir) & #2416938 (Phoenix)
Stop!	Ça suffit !	CC-BY 2.0 (France) Attribution: tato
```

In [4]:

```
def preprocess_raw(text):
    text = text.replace('\u202f', ' ').replace('\xa0', ' ')
    out = ''
    for i, char in enumerate(text.lower()):
        if char in (',', '!', '.') and i > 0 and text[i-1] != ' ':
            out += ' '
        out += char
    return out

text = preprocess_raw(raw_text)
print(text[0:1000])
```

```
go .	va !	cc-by 2 .0 (france) attribution: tatoeba .org #2877272 (cm) & #1158250 (wittydev)
hi .	salut !	cc-by 2 .0 (france) attribution: tatoeba .org #538123 (cm) & #509819 (aiji)
hi .	salut .	cc-by 2 .0 (france) attribution: tatoeba .org #538123 (cm) & #4320462 (gillux)
run !	cours !	cc-by 2 .0 (france) attribution: tatoeba .org #906328 (papabear) & #906331 (sacredcelt
run !	courez !	cc-by 2 .0 (france) attribution: tatoeba .org #906328 (papabear) & #906332 (sacredcelt
who?	qui ?	cc-by 2 .0 (france) attribution: tatoeba .org #2083030 (ck) & #4366796 (gillux)
wow !	ça alors !	cc-by 2 .0 (france) attribution: tatoeba .org #52027 (zifre) & #374631 (zmoo)
fire !	au feu !	cc-by 2 .0 (france) attribution: tatoeba .org #1829639 (spamster) & #4627939 (sacredcelt
help !	à l'aide !	cc-by 2 .0 (france) attribution: tatoeba .org #435084 (lukaszpp) & #128430 (sysko)
jump .	saute .	cc-by 2 .0 (france) attribution: tatoeba .org #631038 (shishir) & #2416938 (phoenix)
stop !	ça suffit !	cc-b
```

字符在计算机里是以编码的形式存在，我们通常所用的空格是 \x20 ，是在标准ASCII可见字符 0x20~0x7e 范围内。

而 \xa0 属于 latin1 （ISO/IEC_8859-1）中的扩展字符集字符，代表不间断空白符nbsp(non-breaking space)，超出gbk编码范围，是需要去除的特殊字符。再数据预处理的过程中，我们首先需要对数据进行清洗。

分词

字符串---单词组成的列表

In [5]:

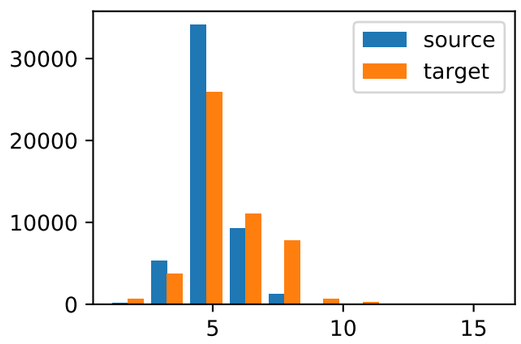
```
num_examples = 50000
source, target = [], []
for i, line in enumerate(text.split('\n')):
    if i > num_examples:
        break
    parts = line.split('\t')
    if len(parts) >= 2:
        source.append(parts[0].split(' '))
        target.append(parts[1].split(' '))

source[0:3], target[0:3]
```

Out[5]:

```
([['go', '.'], ['hi', '.'], ['hi', '.']],
 [['va', '!'], ['salut', '!'], ['salut', '.']])
```

In [6]:

```
d2l.d2l.set_figsize()
d2l.d2l.plt.hist([[len(l) for l in source], [len(l) for l in target]],label=['source', 'target'])
d2l.d2l.plt.legend(loc='upper right');
```



建立词典

单词组成的列表---单词id组成的列表

In [7]:

```
def build_vocab(tokens):
    tokens = [token for line in tokens for token in line]
    return d2l.d2l.data.base.Vocab(tokens, min_freq=3, use_special_tokens=True)

src_vocab = build_vocab(source)
len(src_vocab)
```

Out[7]:

```
3789
```

```
class Vocab(object): # This class is saved in d2l.
  def __init__(self, tokens, min_freq=0, use_special_tokens=False):
    # sort by frequency and token
    counter = collections.Counter(tokens)
    token_freqs = sorted(counter.items(), key=lambda x: x[0])
    token_freqs.sort(key=lambda x: x[1], reverse=True)
    if use_special_tokens:
      # padding, begin of sentence, end of sentence, unknown
      self.pad, self.bos, self.eos, self.unk = (0, 1, 2, 3)
      tokens = ['<pad>', '<bos>', '<eos>', '<unk>']
    else:
      self.unk = 0
      tokens = ['<unk>']
    tokens += [token for token, freq in token_freqs if freq >= min_freq]
    self.idx_to_token = []
    self.token_to_idx = dict()
    for token in tokens:
      self.idx_to_token.append(token)
      self.token_to_idx[token] = len(self.idx_to_token) - 1

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

  def __getitem__(self, tokens):
    if not isinstance(tokens, (list, tuple)):
      return self.token_to_idx.get(tokens, self.unk)
    else:
      return [self.__getitem__(token) for token in tokens]
```

载入数据集

In [8]:

```
def pad(line, max_len, padding_token):
    if len(line) > max_len:
        return line[:max_len]
    return line + [padding_token] * (max_len - len(line))
pad(src_vocab[source[0]], 10, src_vocab.pad)
```

Out[8]:

```
[38, 4, 0, 0, 0, 0, 0, 0, 0, 0]
```

In [9]:

```
def build_array(lines, vocab, max_len, is_source):
    lines = [vocab[line] for line in lines]
    if not is_source:
        lines = [[vocab.bos] + line + [vocab.eos] for line in lines]
    array = torch.tensor([pad(line, max_len, vocab.pad) for line in lines])
    valid_len = (array != vocab.pad).sum(1) #第一个维度
    return array, valid_len
```

```
[docs]class TensorDataset(Dataset):
    r"""Dataset wrapping tensors.

    Each sample will be retrieved by indexing tensors along the first dimension.

    Arguments:
        *tensors (Tensor): tensors that have the same size of the first dimension.
    """

    def __init__(self, *tensors):
        assert all(tensors[0].size(0) == tensor.size(0) for tensor in tensors)
        self.tensors = tensors

    def __getitem__(self, index):
        return tuple(tensor[index] for tensor in self.tensors)

    def __len__(self):
        return self.tensors[0].size(0)
```

In [10]:

```
def load_data_nmt(batch_size, max_len): # This function is saved in d2l.
    src_vocab, tgt_vocab = build_vocab(source), build_vocab(target)
    src_array, src_valid_len = build_array(source, src_vocab, max_len, True)
    tgt_array, tgt_valid_len = build_array(target, tgt_vocab, max_len, False)
    train_data = data.TensorDataset(src_array, src_valid_len, tgt_array, tgt_valid_len)
    train_iter = data.DataLoader(train_data, batch_size, shuffle=True)
    return src_vocab, tgt_vocab, train_iter
```

In [11]:

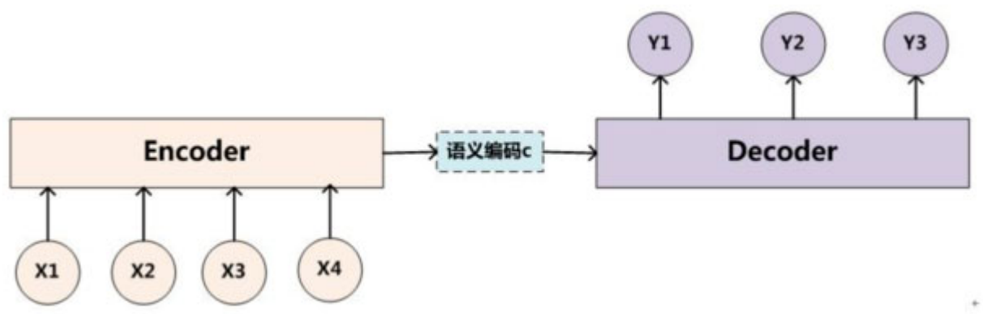
```
src_vocab, tgt_vocab, train_iter = load_data_nmt(batch_size=2, max_len=8)
for X, X_valid_len, Y, Y_valid_len, in train_iter:
    print('X =', X.type(torch.int32), '\nValid lengths for X =', X_valid_len,
        '\nY =', Y.type(torch.int32), '\nValid lengths for Y =', Y_valid_len)
    break
```

```
X = tensor([[108,  71, 360,  85,   0,   0,   0,   0],
        [ 23, 182,  10, 219,   4,   0,   0,   0]], dtype=torch.int32)
Valid lengths for X = tensor([4, 5])
Y = tensor([[   1,  161,   38,   39, 2785,    6,    2,    0],
        [   1,    9,  743,   20,   58,   13,    2,    0]], dtype=torch.int32)
Valid lengths for Y = tensor([7, 7])
```

Encoder-Decoder

encoder：输入到隐藏状态

decoder：隐藏状态到输出



In [12]:

```
class Encoder(nn.Module):
    def __init__(self, **kwargs):
        super(Encoder, self).__init__(**kwargs)

    def forward(self, X, *args):
        raise NotImplementedError
```

In [13]:

```
class Decoder(nn.Module):
    def __init__(self, **kwargs):
        super(Decoder, self).__init__(**kwargs)

    def init_state(self, enc_outputs, *args):
        raise NotImplementedError

    def forward(self, X, state):
        raise NotImplementedError
```

In [14]:

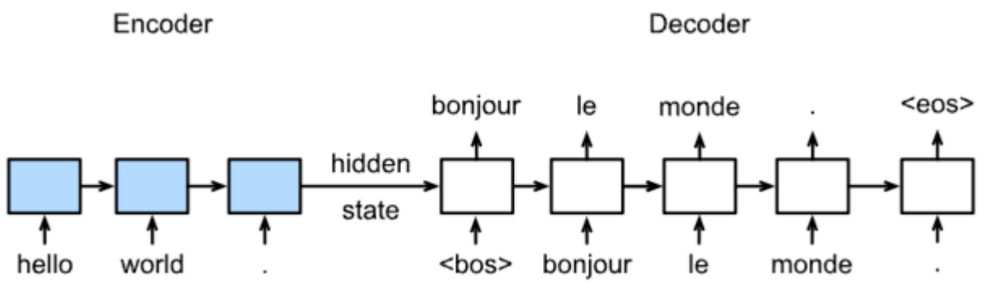
```
class EncoderDecoder(nn.Module):
    def __init__(self, encoder, decoder, **kwargs):
        super(EncoderDecoder, self).__init__(**kwargs)
        self.encoder = encoder
        self.decoder = decoder

    def forward(self, enc_X, dec_X, *args):
        enc_outputs = self.encoder(enc_X, *args)
        dec_state = self.decoder.init_state(enc_outputs, *args)
        return self.decoder(dec_X, dec_state)
```

可以应用在对话系统、生成式任务中。

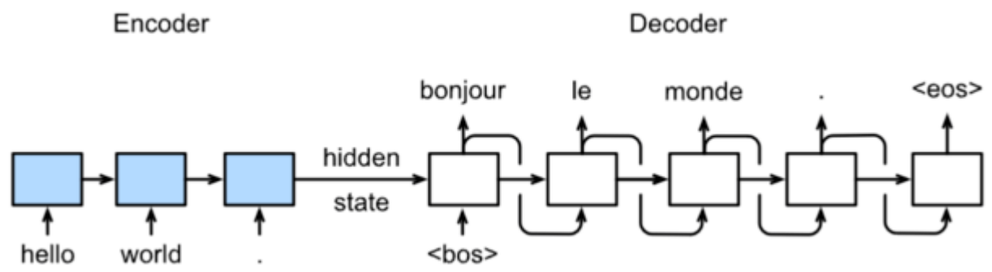
Sequence to Sequence模型

模型：

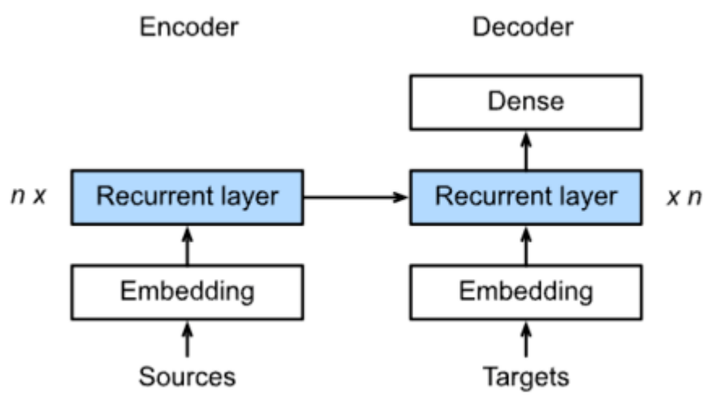
训练



预测



具体结构：



Encoder

In [15]:

```
class Seq2SeqEncoder(d2l.d2l.Encoder):
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0, **kwargs):
        super(Seq2SeqEncoder, self).__init__(**kwargs)
        self.num_hiddens=num_hiddens
        self.num_layers=num_layers
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = nn.LSTM(embed_size,num_hiddens, num_layers, dropout=dropout)

    def begin_state(self, batch_size, device):
        return [torch.zeros(size=(self.num_layers, batch_size, self.num_hiddens),  device=device),
                torch.zeros(size=(self.num_layers, batch_size, self.num_hiddens),  device=device)]
    def forward(self, X, *args):
        X = self.embedding(X) # X shape: (batch_size, seq_len, embed_size)
        X = X.transpose(0, 1)  # RNN needs first axes to be time
        # state = self.begin_state(X.shape[1], device=X.device)
        out, state = self.rnn(X)
        # The shape of out is (seq_len, batch_size, num_hiddens).
        # state contains the hidden state and the memory cell
        # of the last time step, the shape is (num_layers, batch_size, num_hiddens)
        return out, state
```

In [16]:

```
encoder = Seq2SeqEncoder(vocab_size=10, embed_size=8,num_hiddens=16, num_layers=2)
X = torch.zeros((4, 7),dtype=torch.long)
output, state = encoder(X)
output.shape, len(state), state[0].shape, state[1].shape
```

Out[16]:

```
(torch.Size([7, 4, 16]), 2, torch.Size([2, 4, 16]), torch.Size([2, 4, 16]))
```

Decoder

In [17]:

```
class Seq2SeqDecoder(d2l.d2l.Decoder):
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0, **kwargs):
        super(Seq2SeqDecoder, self).__init__(**kwargs)
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = nn.LSTM(embed_size,num_hiddens, num_layers, dropout=dropout)
        self.dense = nn.Linear(num_hiddens,vocab_size)

    def init_state(self, enc_outputs, *args):
        return enc_outputs[1]

    def forward(self, X, state):
        X = self.embedding(X).transpose(0, 1)
        out, state = self.rnn(X, state)
        # Make the batch to be the first dimension to simplify loss computation.
        out = self.dense(out).transpose(0, 1)
        return out, state
```

In [18]:

```
decoder = Seq2SeqDecoder(vocab_size=10, embed_size=8,num_hiddens=16, num_layers=2)
state = decoder.init_state(encoder(X))
out, state = decoder(X, state)
out.shape, len(state), state[0].shape, state[1].shape
```

Out[18]:

```
(torch.Size([4, 7, 10]), 2, torch.Size([2, 4, 16]), torch.Size([2, 4, 16]))
```

损失函数

In [19]:

```
def SequenceMask(X, X_len,value=0):
    maxlen = X.size(1)
    mask = torch.arange(maxlen)[None, :].to(X_len.device) < X_len[:, None]
    X[~mask]=value
    return X
```

In [20]:

```
X = torch.tensor([[1,2,3], [4,5,6]])
SequenceMask(X,torch.tensor([1,2]))
```

Out[20]:

```
tensor([[1, 0, 0],
        [4, 5, 0]])
```

In [21]:

```
X = torch.ones((2,3, 4))
SequenceMask(X, torch.tensor([1,2]),value=-1)
```

Out[21]:

```
tensor([[[ 1.,  1.,  1.,  1.],
         [-1., -1., -1., -1.],
         [-1., -1., -1., -1.]],

        [[ 1.,  1.,  1.,  1.],
         [ 1.,  1.,  1.,  1.],
         [-1., -1., -1., -1.]]])
```

In [22]:

```
class MaskedSoftmaxCELoss(nn.CrossEntropyLoss):
    # pred shape: (batch_size, seq_len, vocab_size)
    # label shape: (batch_size, seq_len)
    # valid_length shape: (batch_size, )
    def forward(self, pred, label, valid_length):
        # the sample weights shape should be (batch_size, seq_len)
        weights = torch.ones_like(label)
        weights = SequenceMask(weights, valid_length).float()
        self.reduction='none'
        output=super(MaskedSoftmaxCELoss, self).forward(pred.transpose(1,2), label)
        return (output*weights).mean(dim=1)
```

In [23]:

```
loss = MaskedSoftmaxCELoss()
loss(torch.ones((3, 4, 10)), torch.ones((3,4),dtype=torch.long), torch.tensor([4,3,0]))
```

Out[23]:

```
tensor([2.3026, 1.7269, 0.0000])
```

训练

In [26]:

```
def train_ch7(model, data_iter, lr, num_epochs, device):  # Saved in d2l
    model.to(device)
    optimizer = optim.Adam(model.parameters(), lr=lr)
    loss = MaskedSoftmaxCELoss()
    tic = time.time()
    for epoch in range(1, num_epochs+1):
        l_sum, num_tokens_sum = 0.0, 0.0
        for batch in data_iter:
            optimizer.zero_grad()
            X, X_vlen, Y, Y_vlen = [x.to(device) for x in batch]
            Y_input, Y_label, Y_vlen = Y[:,:-1], Y[:,1:], Y_vlen-1

            Y_hat, _ = model(X, Y_input, X_vlen, Y_vlen)
            l = loss(Y_hat, Y_label, Y_vlen).sum()
            l.backward()
            with torch.no_grad():
                d2l.d2l.grad_clipping_nn(model, 5, device)
            num_tokens = Y_vlen.sum().item()
            optimizer.step()
            l_sum += l.sum().item()
            num_tokens_sum += num_tokens
        if epoch % 50 == 0:
            print("epoch {0:4d},loss {1:.3f}, time {2:.1f} sec".format(
                  epoch, (l_sum/num_tokens_sum), time.time()-tic))
            tic = time.time()
```

In [28]:

```
embed_size, num_hiddens, num_layers, dropout = 32, 32, 2, 0.0
batch_size, num_examples, max_len = 64, 1e3, 10
lr, num_epochs, ctx = 0.005, 50, d2l.d2l.try_gpu()
src_vocab, tgt_vocab, train_iter = d2l.d2l.load_data_nmt(
    batch_size, max_len,num_examples)
encoder = Seq2SeqEncoder(
    len(src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqDecoder(
    len(tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.d2l.EncoderDecoder(encoder, decoder)
train_ch7(model, train_iter, lr, num_epochs, ctx)
```

```
epoch   50,loss 0.101, time 45.9 sec
```

测试

In [29]:

```
def translate_ch7(model, src_sentence, src_vocab, tgt_vocab, max_len, device):
    src_tokens = src_vocab[src_sentence.lower().split(' ')]
    src_len = len(src_tokens)
    if src_len < max_len:
        src_tokens += [src_vocab.pad] * (max_len - src_len)
    enc_X = torch.tensor(src_tokens, device=device)
    enc_valid_length = torch.tensor([src_len], device=device)
    # use expand_dim to add the batch_size dimension.
    enc_outputs = model.encoder(enc_X.unsqueeze(dim=0), enc_valid_length)
    dec_state = model.decoder.init_state(enc_outputs, enc_valid_length)
    dec_X = torch.tensor([tgt_vocab.bos], device=device).unsqueeze(dim=0)
    predict_tokens = []
    for _ in range(max_len):
        Y, dec_state = model.decoder(dec_X, dec_state)
        # The token with highest score is used as the next time step input.
        dec_X = Y.argmax(dim=2)
        py = dec_X.squeeze(dim=0).int().item()
        if py == tgt_vocab.eos:
            break
        predict_tokens.append(py)
    return ' '.join(tgt_vocab.to_tokens(predict_tokens))
```

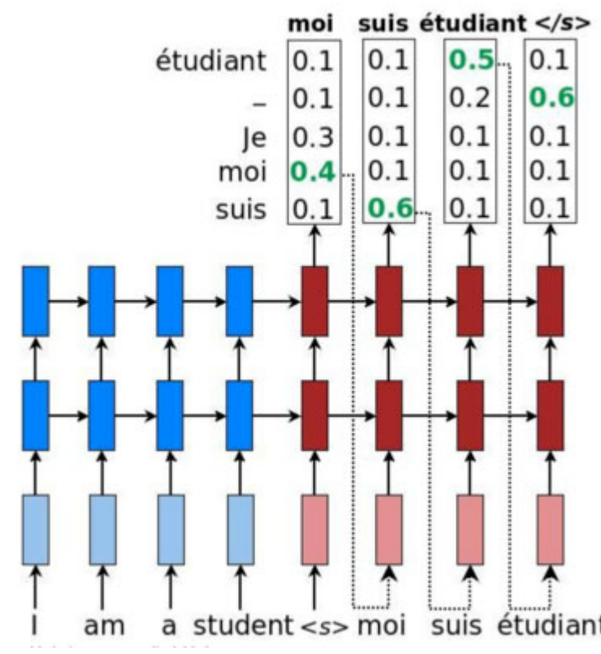
In [30]:

```
for sentence in ['Go .', 'Wow !', "I'm OK .", 'I won !']:
    print(sentence + ' => ' + translate_ch7(
        model, sentence, src_vocab, tgt_vocab, max_len, ctx))
```

```
Go . => <unk> !
Wow ! => <unk> !
I'm OK . => je suis bien <unk> .
I won ! => je l'ai vu .
```

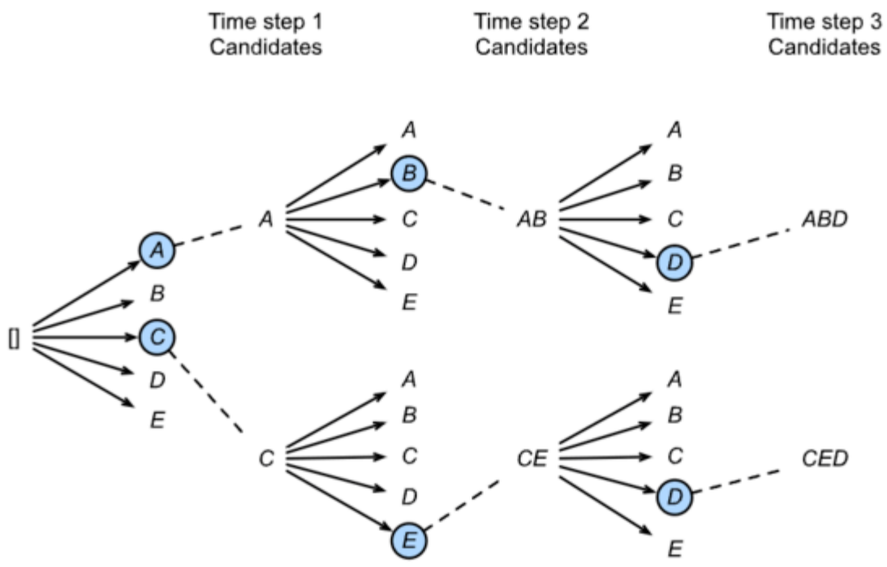
Beam Search

简单greedy search：



维特比算法：选择整体分数最高的句子（搜索空间太大）

集束搜索：



In [ ]: