```
!pip install setuptools==66
!pip install d2l==1.0.0-beta0

import cv2
import numpy as np
import pandas as pd
from tqdm import tqdm
from datetime import datetime
from matplotlib import pyplot as plt

import torch
from torch import nn
from d2l import torch as d2l
from torch.nn import functional as F

!pip install ptflops
import ptflops
from ptflops import get_model_complexity_info

import collections
import math
```

```
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting setuptools==66
  Downloading setuptools-66.0.0-py3-none-any.whl (1.3 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.3/1.3 MB 14.1 MB/s eta 0:00:00
Installing collected packages: setuptools
  Attempting uninstall: setuptools
    Found existing installation: setuptools 67.6.1
    Uninstalling setuptools-67.6.1:
      Successfully uninstalled setuptools-67.6.1
ERROR: pip's dependency resolver does not currently take into account all the packages that are installed. This behaviour is the
ipython 7.34.0 requires jedi>=0.16, which is not installed.
Successfully installed setuptools-66.0.0
Looking in indexes: https://pypi.org/simple, https://us-python.pkg.dev/colab-wheels/public/simple/
Collecting d2l==1.0.0-beta0
  Downloading d2l-1.0.0b0-py3-none-any.whl (141 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 141.6/141.6 kB 5.0 MB/s eta 0:00:00
Collecting gym==0.21.0
  Downloading gym-0.21.0.tar.gz (1.5 MB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 1.5/1.5 MB 39.1 MB/s eta 0:00:00
  Preparing metadata (setup.py) ... done
Collecting gpytorch
  Downloading gpytorch-1.10-py3-none-any.whl (255 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 255.2/255.2 kB 27.0 MB/s eta 0:00:00
Requirement already satisfied: pandas in /usr/local/lib/python3.9/dist-packages (from d2l==1.0.0-beta0) (1.5.3)
Requirement already satisfied: requests in /usr/local/lib/python3.9/dist-packages (from d2l==1.0.0-beta0) (2.27.1)
Requirement already satisfied: matplotlib-inline in /usr/local/lib/python3.9/dist-packages (from d2l==1.0.0-beta0) (0.1.6)
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Requirement already satisfied: numpy in /usr/local/lib/python3.9/dist-packages (from d2l==1.0.0-beta0) (1.22.4)
Collecting jupyter
  Downloading jupyter-1.0.0-py2.py3-none-any.whl (2.7 kB)
Requirement already satisfied: cloudpickle>=1.2.0 in /usr/local/lib/python3.9/dist-packages (from gym==0.21.0->d2l==1.0.0-beta0)
Collecting linear-operator>=0.4.0
  Downloading linear_operator-0.4.0-py3-none-any.whl (156 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 156.7/156.7 kB 17.6 MB/s eta 0:00:00
Requirement already satisfied: scikit-learn in /usr/local/lib/python3.9/dist-packages (from gpytorch->d2l==1.0.0-beta0) (1.2.2)
Requirement already satisfied: notebook in /usr/local/lib/python3.9/dist-packages (from jupyter->d2l==1.0.0-beta0) (6.4.8)
Requirement already satisfied: ipykernel in /usr/local/lib/python3.9/dist-packages (from jupyter->d2l==1.0.0-beta0) (5.5.6)
Requirement already satisfied: ipywidgets in /usr/local/lib/python3.9/dist-packages (from jupyter->d2l==1.0.0-beta0) (7.7.1)
Requirement already satisfied: jupyter-console in /usr/local/lib/python3.9/dist-packages (from jupyter->d2l==1.0.0-beta0) (6.1.0
Requirement already satisfied: nbconvert in /usr/local/lib/python3.9/dist-packages (from jupyter->d2l==1.0.0-beta0) (6.5.4)
Collecting qtconsole
  Downloading qtconsole-5.4.2-py3-none-any.whl (121 kB)
     ━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━━ 121.2/121.2 kB 14.9 MB/s eta 0:00:00
Requirement already satisfied: packaging>=20.0 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (23
Requirement already satisfied: python-dateutil>=2.7 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0
Requirement already satisfied: cycler>=0.10 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (0.11.(
Requirement already satisfied: contourpy>=1.0.1 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (1
Requirement already satisfied: fonttools>=4.22.0 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (4
Requirement already satisfied: pillow>=6.2.0 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (8.4.(
Requirement already satisfied: pyparsing>=2.3.1 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (3
Requirement already satisfied: kiwisolver>=1.0.1 in /usr/local/lib/python3.9/dist-packages (from matplotlib->d2l==1.0.0-beta0) (
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Requirement already satisfied: pytz>=2020.1 in /usr/local/lib/python3.9/dist-packages (from pandas->d2l==1.0.0-beta0) (2022.7.1)
Requirement already satisfied: urllib3<1.27,>=1.21.1 in /usr/local/lib/python3.9/dist-packages (from requests->d2l==1.0.0-beta0)
Requirement already satisfied: charset-normalizer~=2.0.0 in /usr/local/lib/python3.9/dist-packages (from requests->d2l==1.0.0-be
```

```
def init_seq2seq(module):
    """Initialize weights for Seq2Seq."""
    if type(module) == nn.Linear:
         nn.init.xavier_uniform_(module.weight)
```

```
    if type(module) == nn.GRU:
        for param in module._flat_weights_names:
            if "weight" in param:
                nn.init.xavier_uniform_(module._parameters[param])

class Seq2SeqEncoder(d2l.Encoder):
    """The RNN encoder for sequence to sequence learning."""
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = d2l.GRU(embed_size, num_hiddens, num_layers, dropout)
        self.apply(init_seq2seq)

    def forward(self, X, *args):
        # X shape: (batch_size, num_steps)
        embs = self.embedding(X.t().type(torch.int64))
        # embs shape: (num_steps, batch_size, embed_size)
        outputs, state = self.rnn(embs)
        # outputs shape: (num_steps, batch_size, num_hiddens)
        # state shape: (num_layers, batch_size, num_hiddens)
        return outputs, state


vocab_size, embed_size, num_hiddens, num_layers = 10, 8, 16, 2
batch_size, num_steps = 4, 9

encoder = d2l.Seq2SeqEncoder(vocab_size, embed_size, num_hiddens, num_layers)

X = torch.zeros((batch_size, num_steps))
enc_outputs, enc_state = encoder(X)

d2l.check_shape(enc_outputs, (num_steps, batch_size, num_hiddens))



d2l.check_shape(enc_state, (num_layers, batch_size, num_hiddens))


class Seq2SeqDecoder(d2l.Decoder):
    """The RNN decoder for sequence to sequence learning."""
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = d2l.GRU(embed_size+num_hiddens, num_hiddens,
                           num_layers, dropout)
        self.dense = nn.LazyLinear(vocab_size)
        self.apply(init_seq2seq)

    def init_state(self, enc_all_outputs, *args):
        return enc_all_outputs

    def forward(self, X, state):
        # X shape: (batch_size, num_steps)
        # embs shape: (num_steps, batch_size, embed_size)
        embs = self.embedding(X.t().type(torch.int32))
        enc_output, hidden_state = state
        # context shape: (batch_size, num_hiddens)
        context = enc_output[-1]
        # Broadcast context to (num_steps, batch_size, num_hiddens)
        context = context.repeat(embs.shape[0], 1, 1)
        # Concat at the feature dimension
        embs_and_context = torch.cat((embs, context), -1)
        outputs, hidden_state = self.rnn(embs_and_context, hidden_state)
        outputs = self.dense(outputs).swapaxes(0, 1)
        # outputs shape: (batch_size, num_steps, vocab_size)
        # hidden_state shape: (num_layers, batch_size, num_hiddens)
        return outputs, [enc_output, hidden_state]


decoder = Seq2SeqDecoder(vocab_size, embed_size, num_hiddens, num_layers)
state = decoder.init_state(encoder(X))
dec_outputs, state = decoder(X, state)
d2l.check_shape(dec_outputs, (batch_size, num_steps, vocab_size))
d2l.check_shape(state[1], (num_layers, batch_size, num_hiddens))
```

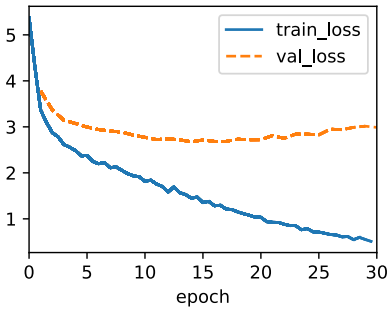
```
/usr/local/lib/python3.9/dist-packages/torch/nn/modules/lazy.py:180: UserWarning: Lazy modules are a new feature under heavy develo
  warnings.warn('Lazy modules are a new feature under heavy development '
```

```
class Seq2Seq(d2l.EncoderDecoder):
    """The RNN encoder-decoder for sequence to sequence learning."""
```

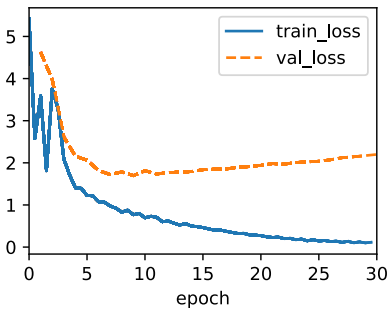
```
    def __init__(self, encoder, decoder, tgt_pad, lr):
        super().__init__(encoder, decoder)
        self.save_hyperparameters()

    def validation_step(self, batch):
        Y_hat = self(*batch[:-1])
        self.plot('loss', self.loss(Y_hat, batch[-1]), train=False)

    def configure_optimizers(self):
        # Adam optimizer is used here
        return torch.optim.Adam(self.parameters(), lr=self.lr)


@d2l.add_to_class(Seq2Seq)
def loss(self, Y_hat, Y):
    l = super(Seq2Seq, self).loss(Y_hat, Y, averaged=False)
    mask = (Y.reshape(-1) != self.tgt_pad).type(torch.float32)
    return (l * mask).sum() / mask.sum()
```

**Adjust the hyperparameters to improve the translation results, embed_size, num_hiddens, num_layers, dropout = 512, 512, 2, 0.2 lr= 0.oo1, Batch size= 256**

```
data = d2l.MTFraEng(batch_size=256)
embed_size, num_hiddens, num_layers, dropout = 512, 512, 2, 0.2
encoder = Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab['<pad>'],
                lr=0.001)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```



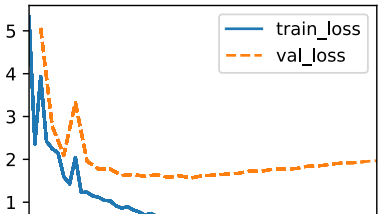

```
embed_size, num_hiddens, num_layers, dropout = 256, 512, 2, 0.3
encoder = Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




**question 1.2**

```
class Seq2SeqEncoder(d2l.Encoder):
    """The RNN encoder for sequence to sequence learning."""
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
```

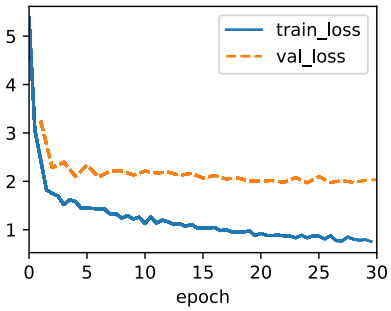
```
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = d2l.GRU(embed_size, num_hiddens, num_layers, dropout)
        self.apply(init_seq2seq)

    def forward(self, X, *args):
        # X shape: (batch_size, num_steps)
        embs = self.embedding(X.t().type(torch.int64))
        # embs shape: (num_steps, batch_size, embed_size)
        outputs, state = self.rnn(embs)
        # outputs shape: (num_steps, batch_size, num_hiddens)
        # state shape: (num_layers, batch_size, num_hiddens)
        return outputs, state



vocab_size, embed_size, num_hiddens, num_layers = 10, 8, 16, 2
batch_size, num_steps = 4, 9
encoder = Seq2SeqEncoder(vocab_size, embed_size, num_hiddens, num_layers)
X = torch.zeros((batch_size, num_steps))
enc_outputs, enc_state = encoder(X)



d2l.check_shape(enc_outputs, (num_steps, batch_size, num_hiddens))


class Seq2SeqDecoder(d2l.Decoder):
    """The RNN decoder for sequence to sequence learning."""
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = d2l.GRU(embed_size+num_hiddens, num_hiddens,
                           num_layers, dropout)
        self.dense = nn.LazyLinear(vocab_size)
        self.apply(init_seq2seq)

    def init_state(self, enc_outputs, *args):
        enc_output, hidden_state = enc_outputs
        hidden_state = hidden_state.mean(dim=0, keepdim=True)
        hidden_state = hidden_state.repeat(self.rnn.num_layers, 1, 1)
        return enc_output, hidden_state

    def forward(self, X, state):
        # X shape: (batch_size, num_steps)
        # embs shape: (num_steps, batch_size, embed_size)
        embs = self.embedding(X.t().type(torch.int32))
        enc_output, hidden_state = state
        # context shape: (batch_size, num_hiddens)
        context = enc_output[-1]
        # Broadcast context to (num_steps, batch_size, num_hiddens)
        context = context.repeat(embs.shape[0], 1, 1)
        # Concat at the feature dimension
        embs_and_context = torch.cat((embs, context), -1)
        outputs, hidden_state = self.rnn(embs_and_context, hidden_state)
        outputs = self.dense(outputs).swapaxes(0, 1)
        # outputs shape: (batch_size, num_steps, vocab_size)
        # hidden_state shape: (num_layers, batch_size, num_hiddens)
        return outputs, [enc_output, hidden_state]


decoder = Seq2SeqDecoder(vocab_size, embed_size, num_hiddens, num_layers)
state = decoder.init_state(encoder(X))
dec_outputs, state = decoder(X, state)
d2l.check_shape(dec_outputs, (batch_size, num_steps, vocab_size))
d2l.check_shape(state[1], (num_layers, batch_size, num_hiddens))



embed_size, num_hiddens, num_layers, dropout = 384, 512, 3, 0.02
encoder = Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, 3, dropout)
decoder = Seq2SeqDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, 2, dropout)
model = Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




**LSTM MODEL**

```
class LSTM(d2l.RNN):
    def __init__(self, num_inputs, num_hiddens,num_layers=1,dropout=0):
        d2l.Module.__init__(self)
        self.save_hyperparameters()
        self.rnn = nn.LSTM(num_inputs, num_hiddens,num_layers,dropout=dropout)

    def forward(self, inputs, H_C=None):
        return self.rnn(inputs, H_C)



class S2SEncoder_LSTM(d2l.Encoder):
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = LSTM(embed_size, num_hiddens, num_layers, dropout)
        self.apply(init_seq2seq)

    def forward(self, X, *args):
        embs = self.embedding(X.t().type(torch.int64))
        outputs, state = self.rnn(embs)
        return outputs, state



vocab_size, embed_size, num_hiddens, num_layers = 10, 8, 16, 2
batch_size, num_steps = 4, 9
encoder = S2SEncoder_LSTM(vocab_size, embed_size, num_hiddens, num_layers)
X = torch.zeros((batch_size, num_steps))
enc_outputs, enc_state = encoder(X)


class S2SDecoder_LSTM(d2l.Decoder):
    """The RNN decoder for sequence to sequence learning."""
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = LSTM(embed_size+num_hiddens, num_hiddens,
                        num_layers, dropout)
        self.dense = nn.LazyLinear(vocab_size)
        self.apply(init_seq2seq)

    def init_state(self, enc_all_outputs, *args):
        return enc_all_outputs

    def forward(self, X, state):
        embs = self.embedding(X.t().type(torch.int32))
        enc_output, hidden_state = state
        context = enc_output[-1]
        context = context.repeat(embs.shape[0], 1, 1)
        embs_and_context = torch.cat((embs, context), -1)
        outputs, hidden_state = self.rnn(embs_and_context, hidden_state)
        outputs = self.dense(outputs).swapaxes(0, 1)
        return outputs, [enc_output, hidden_state]



decoder = S2SDecoder_LSTM(vocab_size, embed_size, num_hiddens, num_layers)
state = decoder.init_state(encoder(X))
dec_outputs, state = decoder(X, state)
d2l.check_shape(dec_outputs, (batch_size, num_steps, vocab_size))



embed_size, num_hiddens, num_layers, dropout = 384, 512, 3, 0.3
encoder = S2SEncoder_LSTM(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = S2SDecoder_LSTM(
```

```
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```



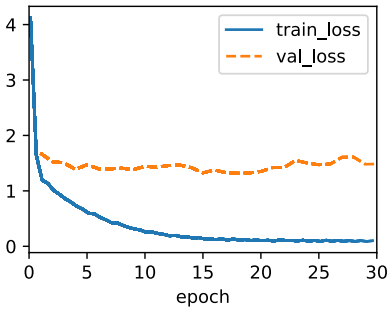

**Q:2- Explore the impacts of number of hidden layers starting tom 1 hidden layer up to 4 hidden layers.**

**In Class Example with 1 hidden layers**

```
class AttentionDecoder(d2l.Decoder):
    """The base attention-based decoder interface."""
    def __init__(self):
        super().__init__()

    @property
    def attention_weights(self):
        raise NotImplementedError


class Seq2SeqAttentionDecoder(AttentionDecoder):
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.attention = d2l.AdditiveAttention(num_hiddens, dropout)
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = nn.GRU(
            embed_size + num_hiddens, num_hiddens, num_layers,
            dropout=dropout)
        self.dense = nn.LazyLinear(vocab_size)
        self.apply(d2l.init_seq2seq)

    def init_state(self, enc_outputs, enc_valid_lens):
        outputs, hidden_state = enc_outputs
        return (outputs.permute(1, 0, 2), hidden_state, enc_valid_lens)

    def forward(self, X, state):
        enc_outputs, hidden_state, enc_valid_lens = state
        X = self.embedding(X).permute(1, 0, 2)
        outputs, self._attention_weights = [], []
        for x in X:
            query = torch.unsqueeze(hidden_state[-1], dim=1)
            context = self.attention(
                query, enc_outputs, enc_outputs, enc_valid_lens)
            x = torch.cat((context, torch.unsqueeze(x, dim=1)), dim=-1)
            out, hidden_state = self.rnn(x.permute(1, 0, 2), hidden_state)
            outputs.append(out)
            self._attention_weights.append(self.attention.attention_weights)
        outputs = self.dense(torch.cat(outputs, dim=0))
        return outputs.permute(1, 0, 2), [enc_outputs, hidden_state,
                                          enc_valid_lens]

    @property
    def attention_weights(self):
        return self._attention_weights


vocab_size, embed_size, num_hiddens, num_layers = 10, 8, 16, 2
batch_size, num_steps = 4, 7
encoder = d2l.Seq2SeqEncoder(vocab_size, embed_size, num_hiddens, num_layers)
decoder = Seq2SeqAttentionDecoder(vocab_size, embed_size, num_hiddens,
                                  num_layers)
X = torch.zeros((batch_size, num_steps), dtype=torch.long)
state = decoder.init_state(encoder(X), None)
output, state = decoder(X, state)
d2l.check_shape(output, (batch_size, num_steps, vocab_size))
```

```
d2l.check_shape(output, (batch_size, num_steps, vocab_size))
d2l.check_shape(state[0], (batch_size, num_steps, num_hiddens))
d2l.check_shape(state[1][0], (batch_size, num_hiddens))
```

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 1, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```



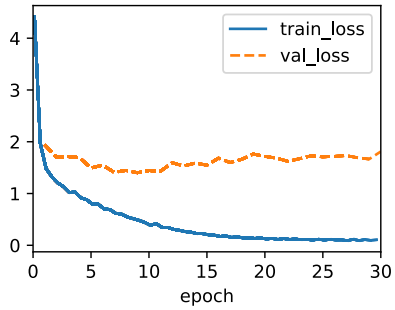

```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ['je', "l'ai", 'vu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>']
he's calm . => ['il', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'malade', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<
```


**With 2 hidden layers**

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 2, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
```

```
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ['je', "l'ai", 'vu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>']
he's calm . => ['il', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'malade', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<
```


### With 3 hidden layers

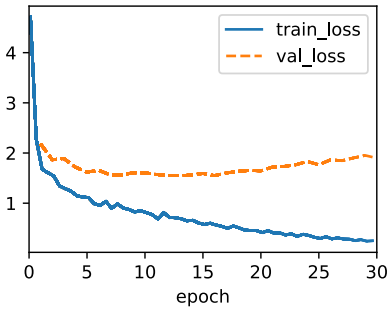
```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 3, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```


```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ['je', "l'ai", 'vu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>']
he's calm . => ['il', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'malade', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<
```


**With 4 hidden layers**

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 4, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
```

```
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
 go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
 i lost . => ['je', "l'ai", 'vu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>']
 he's calm . => ['il', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '
 i'm home . => ['je', 'suis', 'malade', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<
```

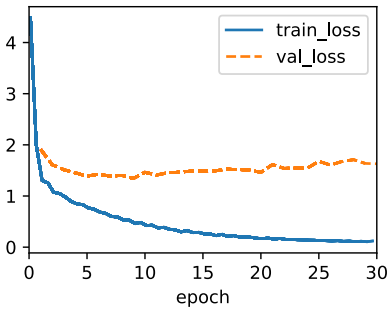

**Replace GRU with LSTM in the experiment. Perform training again. Plot the results**

**With 1 Hidden layer**

```
class Seq2SeqAttentionDecoder_LSTM(AttentionDecoder):
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.attention = d2l.AdditiveAttention(num_hiddens, dropout)
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = nn.LSTM(
            embed_size + num_hiddens, num_hiddens, num_layers,
            dropout=dropout)
        self.dense = nn.LazyLinear(vocab_size)
        self.apply(d2l.init_seq2seq)

    def init_state(self, enc_outputs, enc_valid_lens):
        outputs, hidden_state = enc_outputs
        cell_state = hidden_state.new_zeros(hidden_state.shape)
        return (outputs.permute(1, 0, 2), (hidden_state, cell_state), enc_valid_lens)
    def forward(self, X, state):
        enc_outputs, hidden_and_cell_state, enc_valid_lens = state
        X = self.embedding(X).permute(1, 0, 2)
        outputs, self._attention_weights = [], []
        for x in X:
            query = torch.unsqueeze(hidden_and_cell_state[0][-1], dim=1)
            context = self.attention(
                query, enc_outputs, enc_outputs, enc_valid_lens)
            x = torch.cat((context, torch.unsqueeze(x, dim=1)), dim=-1)
            out, hidden_and_cell_state = self.rnn(x.permute(1, 0, 2), hidden_and_cell_state)
            outputs.append(out)
            self._attention_weights.append(self.attention.attention_weights)
        outputs = self.dense(torch.cat(outputs, dim=0))
        return outputs.permute(1, 0, 2), [enc_outputs, hidden_and_cell_state,
                                          enc_valid_lens]

    @property
    def attention_weights(self):
        return self._attention_weights


vocab_size, embed_size, num_hiddens, num_layers = 10, 8, 16, 2
batch_size, num_steps = 4, 7
encoder = d2l.Seq2SeqEncoder(vocab_size, embed_size, num_hiddens, num_layers)
decoder = Seq2SeqAttentionDecoder_LSTM(vocab_size, embed_size, num_hiddens,
                                       num_layers)
X = torch.zeros((batch_size, num_steps), dtype=torch.long)
state = decoder.init_state(encoder(X), None)
output, state = decoder(X, state)
```

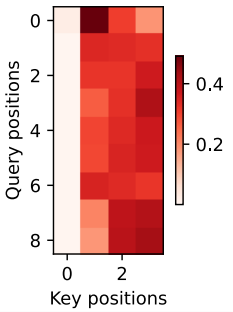
```
d2l.check_shape(output, (batch_size, num_steps, vocab_size))
d2l.check_shape(state[0], (batch_size, num_steps, num_hiddens))
```

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 1, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder_LSTM(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

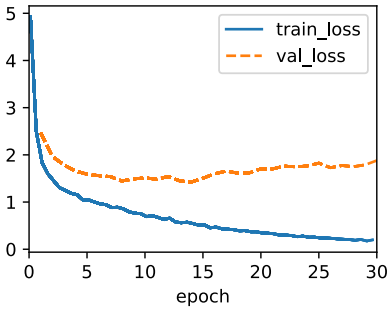
```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ["j'ai", 'perdu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
he's calm . => ['je', 'suis', 'calme', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<
i'm home . => ['je', 'suis', 'chez', 'moi', '.', '<eos>', '<pad>', '<pad>', '<pad>
```




**With 2 Hidden layers**

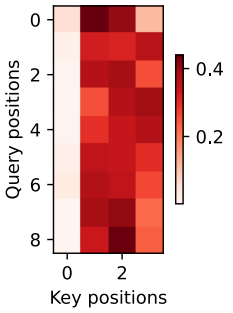
```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 2, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder_LSTM(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
```

```
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ["j'ai", 'perdu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
he's calm . => ['il', 'est', 'mouillé', '.', '<eos>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'chez', 'moi', '.', '<eos>', '<pad>', '<pad>', '<pad>
```

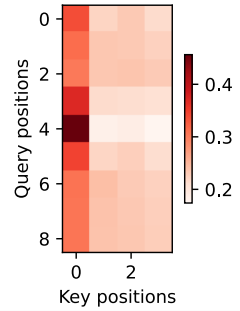



### With 3 Hidden layers

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 3, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder_LSTM(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```

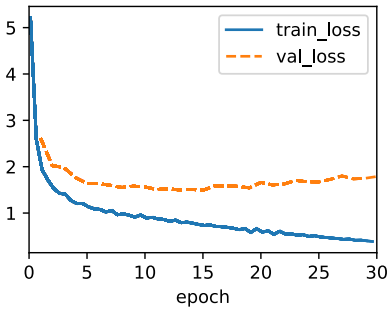

```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad
i lost . => ['j’ai', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
he's calm . => ['il', 'est', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<p
i'm home . => ['je', 'suis', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<p
```




**With 4 Hidden layers**

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 3, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder_LSTM(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
```

```
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['<unk>', 'à', 'la', 'maison', '.', '<eos>', '<pad>', '<pad>', '<pad>'], b
i lost . => ['je', "l'ai", 'vu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>']
he's calm . => ['il', 'est', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<p
i'm home . => ['je', 'suis', '<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<p
```


**Bonus Question**

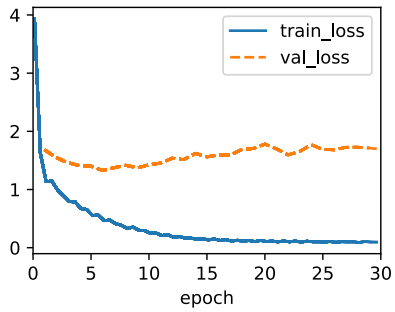
**With 1 Hidden layers**

```
class Seq2SeqAttentionDecoder(AttentionDecoder):
    def __init__(self, vocab_size, embed_size, num_hiddens, num_layers,
                 dropout=0):
        super().__init__()
        self.attention = d2l.DotProductAttention(dropout)
        self.embedding = nn.Embedding(vocab_size, embed_size)
        self.rnn = nn.GRU(
            embed_size + num_hiddens, num_hiddens, num_layers,
            dropout=dropout)
        self.dense = nn.LazyLinear(vocab_size)
        self.apply(d2l.init_seq2seq)

    def init_state(self, enc_outputs, enc_valid_lens):
        outputs, hidden_state = enc_outputs
        return (outputs.permute(1, 0, 2), hidden_state, enc_valid_lens)
    def forward(self, X, state):
        enc_outputs, hidden_state, enc_valid_lens = state
        X = self.embedding(X).permute(1, 0, 2)
        outputs, self._attention_weights = [], []
        for x in X:
            query = torch.unsqueeze(hidden_state[-1], dim=1)
            context = self.attention(
                query, enc_outputs, enc_outputs, enc_valid_lens)
            x = torch.cat((context, torch.unsqueeze(x, dim=1)), dim=-1)
            out, hidden_state = self.rnn(x.permute(1, 0, 2), hidden_state)
            outputs.append(out)
            self._attention_weights.append(self.attention.attention_weights)
        outputs = self.dense(torch.cat(outputs, dim=0))
        return outputs.permute(1, 0, 2), [enc_outputs, hidden_state,
                                          enc_valid_lens]

    @property
    def attention_weights(self):
        return self._attention_weights
```

```
vocab_size, embed_size, num_hiddens, num_layers = 10, 8, 16, 2
batch_size, num_steps = 4, 7
encoder = d2l.Seq2SeqEncoder(vocab_size, embed_size, num_hiddens, num_layers)
decoder = Seq2SeqAttentionDecoder(vocab_size, embed_size, num_hiddens,
                                  num_layers)
X = torch.zeros((batch_size, num_steps), dtype=torch.long)
state = decoder.init_state(encoder(X), None)
```

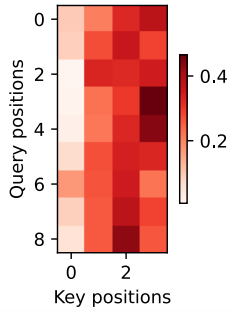
```
output, state = decoder(X, state)
d2l.check_shape(output, (batch_size, num_steps, vocab_size))
d2l.check_shape(state[0], (batch_size, num_steps, num_hiddens))
d2l.check_shape(state[1][0], (batch_size, num_hiddens))
```

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 1, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

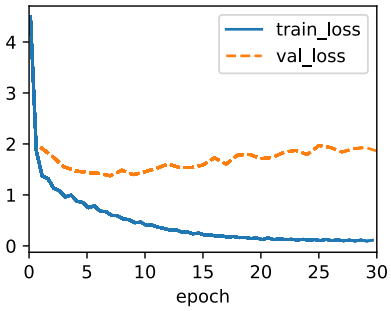
```
 go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
 i lost . => ["j'ai", 'perdu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
 he's calm . => ['<unk>', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>'
 i'm home . => ['je', 'suis', 'chez', 'moi', '.', '<eos>', '<pad>', '<pad>', '<pad>
```




**With 2 Hidden layers**

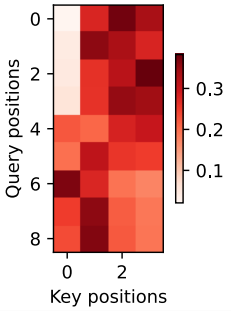
```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 2, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
```

```
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```



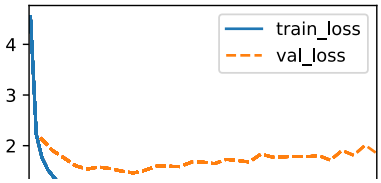

```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ["j'ai", 'perdu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
he's calm . => ['il', 'est', 'mouillé', '.', '<eos>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'chez', 'moi', '.', '<eos>', '<pad>', '<pad>', '<pad>
```



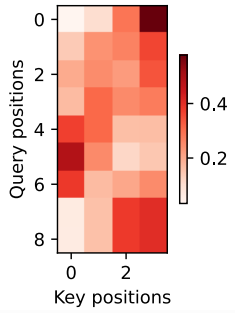

### With 3 Hidden layers

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 3, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```



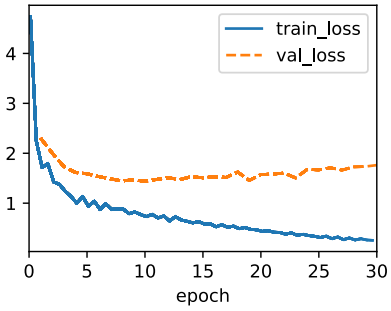

```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ["j'ai", 'perdu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
he's calm . => ['il', 'est', 'mouillé', '.', '<eos>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'chez', 'moi', '.', '<eos>', '<pad>', '<pad>', '<pad>
```




**With 4 Hidden layers**

```
data = d2l.MTFraEng(batch_size=128)
embed_size, num_hiddens, num_layers, dropout = 256, 256, 4, 0.2
encoder = d2l.Seq2SeqEncoder(
    len(data.src_vocab), embed_size, num_hiddens, num_layers, dropout)
decoder = Seq2SeqAttentionDecoder(
    len(data.tgt_vocab), embed_size, num_hiddens, num_layers, dropout)
model = d2l.Seq2Seq(encoder, decoder, tgt_pad=data.tgt_vocab[''],
                    lr=0.005)
trainer = d2l.Trainer(max_epochs=30, gradient_clip_val=1, num_gpus=1)
trainer.fit(model, data)
```




```
engs = ['go .', 'i lost .', 'he\'s calm .', 'i\'m home .']
fras = ['va !', 'j\'ai perdu .', 'il est calme .', 'je suis chez moi .']
preds, _ = model.predict_step(
    data.build(engs, fras), d2l.try_gpu(), data.num_steps)
```

```
for en, fr, p in zip(engs, fras, preds):
    translation = []
    for token in data.tgt_vocab.to_tokens(p):
        if token == '':
            break
        translation.append(token)
    print(f'{en} => {translation}, bleu,'
          f'{d2l.bleu(" ".join(translation), fr, k=2):.3f}')
_, dec_attention_weights = model.predict_step(
    data.build([engs[-1]], [fras[-1]]), d2l.try_gpu(), data.num_steps, True)
attention_weights = torch.cat(
    [step[0][0][0] for step in dec_attention_weights], 0)
attention_weights = attention_weights.reshape((1, 1, -1, data.num_steps))

d2l.show_heatmaps(
    attention_weights[:, :, :, :len(engs[-1].split()) + 1].cpu(),
    xlabel='Key positions', ylabel='Query positions')
```

```
go . => ['va', '!', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>', '<pad>']
i lost . => ["j'ai", 'perdu', '.', '<eos>', '<pad>', '<pad>', '<pad>', '<pad>', '<
he's calm . => ['il', 'est', 'mouillé', '.', '<eos>', '<pad>', '<pad>', '<pad>', '
i'm home . => ['je', 'suis', 'chez', 'moi', '.', '<eos>', '<pad>', '<pad>', '<pad>
```