Deep learning

1.6. Tensor internals

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https://fleuret.org/dlc/
A tensor is a view of a [part of a] **storage**, which is a low-level 1d vector.

```python
>>> x = torch.zeros(2, 4)
>>> x.storage()
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
 0.0
[torch.FloatStorage of size 8]
>>> q = x.storage()
>>> q[4] = 1.0
>>> x
 0.0
 0.0
 0.0
[tensor([[ 0., 0., 0., 0.],
         [ 1., 0., 0., 0.]]])
The first coefficient of a tensor is the one at `storage_offset()` in `storage()`.

```python
>>> q = torch.arange(0., 20.).storage()
>>> x = torch.empty(0).set_(q, storage_offset = 5, size = (3, 2), stride = (4, 1))
>>> x
tensor([[ 5.,  6.],
         [ 9., 10.],
         [13., 14.]])
```
The first coefficient of a tensor is the one at `storage_offset()` in `storage()`.

Incrementing index \( \text{k} \) by 1 move by `stride(\text{k})` elements in the storage.

E.g. in a 2d tensor, incrementing the row index moves by `stride(0)` in the storage, and incrementing the column index moves by `stride(1)`.
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```

$q = \begin{pmatrix}
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19
\end{pmatrix}$
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```

\[
\begin{array}{cccccccccccccccc}
0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 \\
\end{array}
\]

\[
\begin{array}{cccc}
x[0,0] & x[0,1] & x[1,0] & x[1,1] & x[2,0] & x[2,1] \\
\end{array}
\]
The first coefficient of a tensor is the one at \texttt{storage_offset()} in \texttt{storage()}.

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```

$q =$

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
<th>16</th>
<th>17</th>
<th>18</th>
<th>19</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
<td>5</td>
<td>6</td>
<td>7</td>
<td>8</td>
<td>9</td>
<td>10</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
</tr>
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</table>

\[ x[0,0] \ x[0,1] \ x[1,0] \ x[1,1] \ x[2,0] \ x[2,1] \]
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```

$q = \begin{pmatrix} 0 & 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 \\
5 & 6 & 7 & 8 & 9 & 10 & 11 & 12 & 13 & 14 & 15 & 16 & 17 & 18 & 19 \\
\end{pmatrix}$
We can explicitly create different “views” of the same storage

```python
>>> n = torch.linspace(1, 4, 4)
>>> n
tensor([ 1., 2., 3., 4.])
>>> torch.tensor(0.).set_(n.storage(), 1, (3, 3), (0, 1))
tensor([[ 2., 3., 4.],
        [ 2., 3., 4.],
        [ 2., 3., 4.]])
>>> torch.tensor(0.).set_(n.storage(), 1, (2, 4), (1, 0))
tensor([[ 2., 2., 2., 2.],
        [ 3., 3., 3., 3.]])
```
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>>> n
tensor([ 1.,  2.,  3.,  4.])
>>> torch.tensor(0.).set_(n.storage(), 1, (3, 3), (0, 1))
tensor([[ 2.,  3.,  4.],
        [ 2.,  3.,  4.],
        [ 2.,  3.,  4.]])
>>> torch.tensor(0.).set_(n.storage(), 1, (2, 4), (1, 0))
tensor([[ 2.,  2.,  2.,  2.],
        [ 3.,  3.,  3.,  3.]])
```

This is in particular how transpositions and broadcasting are implemented.

```python
>>> x = torch.empty(100, 100)
>>> x.stride()
(100, 1)
>>> y = x.t()
>>> y.stride()
(1, 100)
```
This organization explains the following (maybe surprising) error

```python
>>> x = torch.empty(100, 100)
>>> x.t().view(-1)
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
RuntimeError: invalid argument 2: view size is not compatible with input tensor's size and stride (at least one dimension spans across two contiguous subspaces). Call .contiguous() before .view()
```

`x.t()` shares `x`'s storage and cannot be “flattened” to 1d.
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This can be fixed with `contiguous()`, which returns a contiguous version of the tensor, **making a copy if needed.**

The function `reshape()` combines `view()` and `contiguous()`.
The end