Exploring Fancy Indexing

Fancy indexing is conceptually simple: it means passing an array of indices to access multiple array elements at once. For example, consider the following array:

```
In[1]: import numpy as np
       rand = np.random.RandomState(42)

       x = rand.randint(100, size=10)
       print(x)
```

```
[51 92 14 71 60 20 82 86 74 74]
```

Suppose we want to access three different elements. We could do it like this:

```
In[2]: [x[3], x[7], x[2]]
```

```
Out[2]: [71, 86, 14]
```

Alternatively, we can pass a single list or array of indices to obtain the same result:

```
In[3]: ind = [3, 7, 4]
       x[ind]
```

```
Out[3]: array([71, 86, 60])
```

With fancy indexing, the shape of the result reflects the shape of the *index arrays* rather than the shape of the *array being indexed*:

```
In[4]: ind = np.array([[3, 7],
                       [4, 5]])
       x[ind]
```

```
Out[4]: array([[71, 86],
               [60, 20]])
```

Fancy indexing also works in multiple dimensions. Consider the following array:

```
In[5]: X = np.arange(12).reshape((3, 4))
       X
```

```
Out[5]: array([[ 0,  1,  2,  3],
               [ 4,  5,  6,  7],
               [ 8,  9, 10, 11]])
```

Like with standard indexing, the first index refers to the row, and the second to the column:

```
In[6]: row = np.array([0, 1, 2])
       col = np.array([2, 1, 3])
       X[row, col]
```

```
Out[6]: array([ 2,  5, 11])
```

Notice that the first value in the result is `X[0, 2]`, the second is `X[1, 1]`, and the third is `X[2, 3]`. The pairing of indices in fancy indexing follows all the broadcasting rules that were mentioned in "Computation on Arrays: Broadcasting" on page 63. So,

for example, if we combine a column vector and a row vector within the indices, we get a two-dimensional result:

```
In[7]: X[row[:, np.newaxis], col]

Out[7]: array([[ 2,  1,  3],
               [ 6,  5,  7],
               [10,  9, 11]])
```

Here, each row value is matched with each column vector, exactly as we saw in broadcasting of arithmetic operations. For example:

```
In[8]: row[:, np.newaxis] * col

Out[8]: array([[0, 0, 0],
               [2, 1, 3],
               [4, 2, 6]])
```

It is always important to remember with fancy indexing that the return value reflects the *broadcasted shape of the indices*, rather than the shape of the array being indexed.

Combined Indexing

For even more powerful operations, fancy indexing can be combined with the other indexing schemes we've seen:

```
In[9]: print(X)

[[ 0  1  2  3]
 [ 4  5  6  7]
 [ 8  9 10 11]]
```

We can combine fancy and simple indices:

```
In[10]: X[2, [2, 0, 1]]

Out[10]: array([10,  8,  9])
```

We can also combine fancy indexing with slicing:

```
In[11]: X[1:, [2, 0, 1]]

Out[11]: array([[ 6,  4,  5],
                [10,  8,  9]])
```

And we can combine fancy indexing with masking:

```
In[12]: mask = np.array([1, 0, 1, 0], dtype=bool)
        X[row[:, np.newaxis], mask]

Out[12]: array([[ 0,  2],
                [ 4,  6],
                [ 8, 10]])
```

All of these indexing options combined lead to a very flexible set of operations for accessing and modifying array values.