

NumPy Master Class

Lecture.2
Objects and ndarrays

Lecture.2

Objects and ndarrays

- Objects in Python

Object = Data + Methods

```
a = [1, 2, 3] # instantiate a list  
a.append(4) # use "append" method to append 3 to the list  
print(a)
```

Lecture.2

Objects and ndarrays

- Objects in Python

dir() Function

```
a = [1, 2, 3]
for attr in dir(a):
    print(attr)
```

__add__	__iter__	append
__class__	__le__	clear
__contains__	__len__	copy
__delattr__	__lt__	count
__delitem__	__mul__	extend
__dir__	__ne__	index
__doc__	__new__	insert
__eq__	__reduce__	pop
__format__	__reduce_ex__	remove
__ge__	__repr__	reverse
__getattr__	__reversed__	sort
__getitem__	__rmul__	
__gt__	__setattr__	
__hash__	__setitem__	
__iadd__	__sizeof__	
__imul__	__str__	
__init__	__subclasshook__	
__init_subclass__		

Lecture.2

Objects and ndarrays

- Objects in Python

dir() Function

```
a = {'a':0, 'b':1, 'c':2}
for attr in dir(a):
    print(attr)
```

<code>__class__</code>	<code>__iter__</code>	<code>clear</code>
<code>__contains__</code>	<code>__le__</code>	<code>copy</code>
<code>__delattr__</code>	<code>__len__</code>	<code>fromkeys</code>
<code>__delitem__</code>	<code>__lt__</code>	<code>get</code>
<code>__dir__</code>	<code>__ne__</code>	<code>items</code>
<code>__doc__</code>	<code>__new__</code>	<code>keys</code>
<code>__eq__</code>	<code>__reduce__</code>	<code>pop</code>
<code>__format__</code>	<code>__reduce_ex__</code>	<code>popitem</code>
<code>__ge__</code>	<code>__repr__</code>	<code>setdefault</code>
<code>__getattr__</code>	<code>__setattr__</code>	<code>update</code>
<code>__getitem__</code>	<code>__setitem__</code>	<code>values</code>
<code>__gt__</code>	<code>__sizeof__</code>	
<code>__hash__</code>	<code>__str__</code>	
<code>__init__</code>	<code>__subclasshook__</code>	
<code>__init_subclass__</code>		

Lecture.2

Objects and ndarrays - Objects in Python

dir() Function - Methods of Different Objects

```
a = [1, 2, 3]
for attr in dir(a):
    print(attr)
```

```
append
clear
copy
count
extend
index
insert
pop
remove
reverse
sort
```

```
a = {'a':0, 'b':1, 'c':2}
for attr in dir(a):
    print(attr)
```

```
clear
copy
fromkeys
get
items
keys
pop
popitem
setdefault
update
values
```


Lecture.2

Objects and ndarrays

- Objects in Python

dir() Function - Methods of Same Objects

```
a = [10, 20, 30, 40, 50]
```

```
b = [1.5, 2.5, 3.5, 4.5, 5.5]
```

```
c = ['a', 'b', 'c', 'd', 'e']
```

__add__	__iter__	append
__class__	__le__	clear
__contains__	__len__	copy
__delattr__	__lt__	count
__delitem__	__mul__	extend
__dir__	__ne__	index
__doc__	__new__	insert
__eq__	__reduce__	pop
__format__	__reduce_ex__	remove
__ge__	__repr__	reverse
__getattr__	__reversed__	sort
__getitem__	__rmul__	
__gt__	__setattr__	
__hash__	__setitem__	
__iadd__	__sizeof__	
__imul__	__str__	
__init__	__subclasshook__	
__init_subclass__		

Lecture.2 Objects and ndarrays

- Objects in Python

type() Function

```
a = [1, 2, 3]
```

```
b = {'a':1, 'b':2, 'c':3}
```

```
c = (1, 2, 3)
```

```
print(type(a))    <class 'list'>
```

```
print(type(b))    <class 'dict'>
```

```
print(type(c))    <class 'tuple'>
```


Lecture.2

Objects and ndarrays

- Special Methods

Special Methods of int Objects

```
a, b = 10, 20
```

```
for attr in zip(dir(a), dir(b)):  
    print(attr)
```

```
('__abs__', '__abs__')  
('__add__', '__add__')  
('__and__', '__and__')  
('__bool__', '__bool__')  
('__ceil__', '__ceil__')  
('__class__', '__class__')  
('__delattr__', '__delattr__')  
('__dir__', '__dir__')  
('__divmod__', '__divmod__')  
('__doc__', '__doc__')  
('__eq__', '__eq__')  
('__float__', '__float__')  
('__floor__', '__floor__')  
('__floordiv__', '__floordiv__')  
('__format__', '__format__')  
('__ge__', '__ge__')  
('__getattr__', '__getattr__')  
('__getnewargs__', '__getnewargs__')  
('__gt__', '__gt__')  
('__hash__', '__hash__')  
('__index__', '__index__')  
('__init__', '__init__')  
('__init_subclass__', '__init_subclass__')
```

```
('__int__', '__int__')  
('__invert__', '__invert__')  
('__le__', '__le__')  
('__lshift__', '__lshift__')  
('__lt__', '__lt__')  
('__mod__', '__mod__')  
('__mul__', '__mul__')  
('__ne__', '__ne__')  
('__neg__', '__neg__')  
('__new__', '__new__')  
('__or__', '__or__')  
('__pos__', '__pos__')  
('__pow__', '__pow__')  
('__radd__', '__radd__')  
('__rand__', '__rand__')  
('__rdivmod__', '__rdivmod__')  
('__reduce__', '__reduce__')  
('__reduce_ex__', '__reduce_ex__')  
('__repr__', '__repr__')  
('__rfloordiv__', '__rfloordiv__')  
('__rlshift__', '__rlshift__')  
('__rmod__', '__rmod__')  
('__rmul__', '__rmul__')
```

```
('__ror__', '__ror__')  
('__round__', '__round__')  
('__rpow__', '__rpow__')  
('__rrshift__', '__rrshift__')  
('__rshift__', '__rshift__')  
('__rsub__', '__rsub__')  
('__rtruediv__', '__rtruediv__')  
('__rxor__', '__rxor__')  
('__setattr__', '__setattr__')  
('__sizeof__', '__sizeof__')  
('__str__', '__str__')  
('__sub__', '__sub__')  
('__subclasshook__', '__subclasshook__')  
('__truediv__', '__truediv__')  
('__trunc__', '__trunc__')  
('__xor__', '__xor__')  
('bit_length', 'bit_length')  
('conjugate', 'conjugate')  
('denominator', 'denominator')  
('from_bytes', 'from_bytes')  
('imag', 'imag')  
('numerator', 'numerator')  
('real', 'real')  
('to_bytes', 'to_bytes')
```


Lecture.2 Objects and ndarrays

- Objects in Python

Special Method Examples

```
a, b = 10, 20
```

```
c = a + b
```

```
print(type(a))    <class 'int'>
```

```
print(type(b))    <class 'int'>
```

```
print(type(c))    <class 'int'>
```

```
print(a + b)      30
```

```
print(a.__add__(b)) 30
```

```
a = [1, 2, 3]
```

```
print(len(a))      3
```

```
print(a.__len__()) 3
```

Lecture.2 Objects and ndarrays

- Objects in Python

Special Method Examples

```
a, b = 4, 2
```

```
print(a - b, a.__sub__(b))      2 2
print(a * b, a.__mul__(b))      8 8
print(a ** b, a.__pow__(b))     16 16
print(a / b, a.__truediv__(b))  2.0 2.0
print(a // b, a.__floordiv__(b)) 2 2
print(a % b, a.__mod__(b))      0 0
```


Lecture.2 Objects and ndarrays

- Objects in Python

Special Method Examples

```
a, b, c, d, e = 1.2, 3.5, 4.2, 5.2, 5.1
```

```
result = (a + b)**c - (d / e)
```

```
result = ((a.__add__(b)).__pow__(c)).__sub__(d.__truediv__(e))
```

Lecture.2 Objects and ndarrays - Objects in Python

Different Special Methods in Different Objects

```
a, b = 10, 20  
print(a + b, a * b)      30 200
```

```
list1, list2 = [1, 2, 3], [4, 5, 6]  
print(list1 + list2)      [1, 2, 3, 4, 5, 6]  
print(3*list1)            [1, 2, 3, 1, 2, 3, 1, 2, 3]
```


Lecture.2 Objects and ndarrays - Objects in Python

Different Special Methods in Different Objects

```
import numpy as np

a_list = [1, 2, 3]
b_list = [4, 5, 6]

print("__add__ of lists: ", a_list.__add__(b_list))    __add__ of lists:  [1, 2, 3, 4, 5, 6]

a_np = np.array(a_list)
b_np = np.array(b_list)

print("__add__ of ndarrays: ", a_np.__add__(b_np))    __add__ of ndarrays:  [5 7 9]
```

Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

Namespace and Import

```
import numpy
```

```
print(numpy)
```

```
<module 'numpy' from '/usr/local/lib/python3.7/dist-packages/numpy/__init__.py'>
```

```
import numpy
```

```
scores = [10, 20, 30, 40, 50]
```

```
print("mean: ", numpy.mean(scores))
```

```
mean: 30.0
```

```
print("variance: ", numpy.var(scores))
```

```
variance: 200.0
```


Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

Namespace and Import

```
import numpy as np
```

```
scores = [10, 20, 30, 40, 50]
```

```
print("mean: ", np.mean(scores))
```

```
mean: 30.0
```

```
print("variance: ", np.var(scores))
```

```
variance: 200.0
```

Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

ndarray Objects

```
import numpy as np  
  
a = np.array([1, 2, 3])  
print(type(a))      <class 'numpy.ndarray'>
```


Lecture.2

Objects and ndarrays

- ndarray Object of NumPy

ndarray Objects

```
import numpy as np

a = np.array([1, 2, 3])

for attr in dir(a):
    print(attr)
```

T	__gt__	__new__	__xor__	imag	sum
__abs__	__hash__	__or__	all	item	swapaxes
__add__	__iadd__	__pos__	any	itemset	take
__and__	__iand__	__pow__	argmax	itemsizes	tobytes
__array__	__ifloordiv__	__radd__	argmin	max	tofile
__array_finalize__	__ilshift__	__rand__	argpartition	mean	tolist
__array_function__	__imatmul__	__rdivmod__	argsort	min	tostring
__array_interface__	__imod__	__reduce__	astype	nbytes	trace
__array_prepare__	__imul__	__reduce_ex__	base	ndim	transpose
__array_priority__	__index__	__repr__	byteswap	newbyteorder	var
__array_struct__	__init__	__rfloordiv__	choose	nonzero	view
__array_ufunc__	__init_subclass__	__rlshift__	clip	partition	
__array_wrap__	__int__	__rmatmul__	compress	prod	
__bool__	__invert__	__rmod__	conj	ptp	
__class__	__ior__	__rmul__	conjugate	put	
__complex__	__ipow__	__ror__	copy	ravel	
__contains__	__irshift__	__rpow__	ctypes	real	
__copy__	__isub__	__rrshift__	cumprod	repeat	
__deepcopy__	__iter__	__rshift__	cumsum	reshape	
__delattr__	__itruediv__	__rsub__	data	resize	
__delitem__	__ixor__	__rtruediv__	diagonal	round	
__dir__	__le__	__rxor__	dot	searchsorted	
__divmod__	__len__	__setattr__	dtype	setfield	
__doc__	__lshift__	__setitem__	dump	setflags	
__eq__	__lt__	__setstate__	dumps	shape	
__float__	__matmul__	__sizeof__	fill	size	
__floordiv__	__mod__	__str__	flags	sort	
__format__	__mul__	__sub__	flat	squeeze	
__ge__	__ne__	__subclasshook__	flatten	std	
__getattr__	__neg__	__truediv__	getfield	strides	
__getitem__					

Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

Element-wise Operations of ndarrays

$$\vec{u}^T = (1 \ 2 \ 3) \quad \vec{v}^T = (4 \ 5 \ 6)$$

$$\begin{aligned}\vec{w} &= \vec{u}^T + \vec{v}^T \\ &= (1 \ 2 \ 3) + (4 \ 5 \ 6) \\ &= (5 \ 7 \ 9)\end{aligned}$$

```
u = [1, 2, 3]
v = [4, 5, 6]
```

```
w = u + v
print(w)    [1, 2, 3, 4, 5, 6]
```

```
w = [0]*len(u)
for data_idx in range(len(u)):
    w[data_idx] = u[data_idx] + v[data_idx]
print(w)

[5, 7, 9]
```


Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

Element-wise Operations of ndarrays

with Python Lists

```
u = [1, 2, 3]
v = [4, 5, 6]

w = [0]*len(u)
for data_idx in range(len(u)):
    w[data_idx] = u[data_idx] + v[data_idx]
print(w)

[5, 7, 9]
```

with ndarrays

```
import numpy as np

u = np.array([1, 2, 3])
v = np.array([4, 5, 6])

print(u + v)

[5 7 9]
```

Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

Element-wise Operations of ndarrays

$$M = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix}, \quad N = \begin{pmatrix} 11 & 12 & 13 \\ 14 & 15 & 16 \\ 17 & 18 & 19 \end{pmatrix}$$

$$M + N = \begin{pmatrix} 1 & 2 & 3 \\ 4 & 5 & 6 \\ 7 & 8 & 9 \end{pmatrix} + \begin{pmatrix} 11 & 12 & 13 \\ 14 & 15 & 16 \\ 17 & 18 & 19 \end{pmatrix}$$

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

$$= \begin{pmatrix} 12 & 14 & 16 \\ 18 & 20 & 22 \\ 24 & 26 & 28 \end{pmatrix}$$

```
M = [[1, 2, 3], [4, 5, 6], [7, 8, 9]]  
N = [[11, 12, 13], [14, 15, 16], [17, 18, 19]]
```

```
n_row, n_col = len(M), len(M[0])
```

```
P = [[0]*n_col for _ in range(n_col)]  
for row_idx in range(n_row):  
    for col_idx in range(n_col):  
        P[row_idx][col_idx] = M[row_idx][col_idx] + \  
            N[row_idx][col_idx]
```

```
for P_row in P:  
    print(P_row)    [12, 14, 16]  
                    [18, 20, 22]  
                    [24, 26, 28]
```


Lecture.2 Objects and ndarrays

- ndarray Object of NumPy

Element-wise Operations of ndarrays

with Python Lists

```
M = [[1, 2, 3], [4, 5, 6], [7, 8, 9]]
N = [[11, 12, 13], [14, 15, 16], [17, 18, 19]]

n_row, n_col = len(M), len(M[0])

P = [[0]*n_col for _ in range(n_col)]
for row_idx in range(n_row):
    for col_idx in range(n_col):
        P[row_idx][col_idx] = M[row_idx][col_idx] + \
            N[row_idx][col_idx]

for P_row in P:
    print(P_row)      [12, 14, 16]
                     [18, 20, 22]
                     [24, 26, 28]
```

with ndarrays

```
import numpy as np

M = np.array([[1, 2, 3],
              [4, 5, 6],
              [7, 8, 9]])

N = np.array([[11, 12, 13],
              [14, 15, 16],
              [17, 18, 19]])

print(M + N)

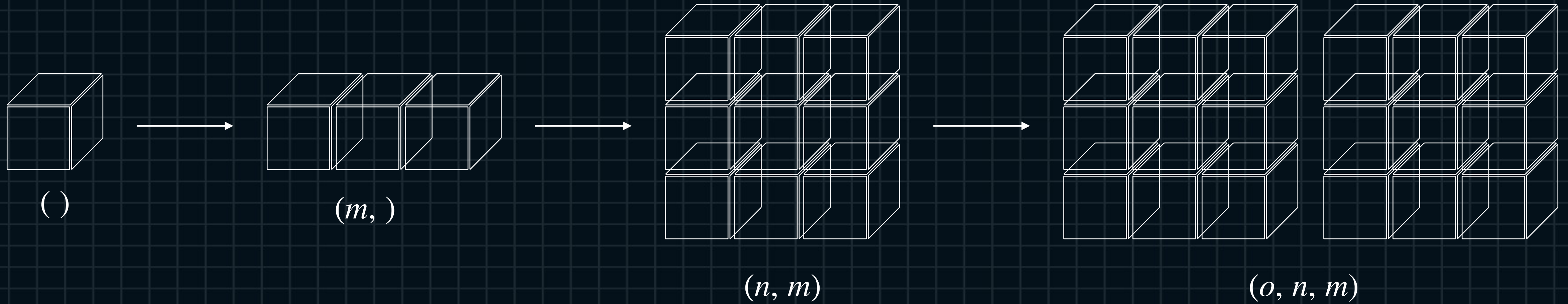
[[12 14 16]
 [18 20 22]
 [24 26 28]]
```

Lecture.2

Objects and ndarrays

- Tensors and ndarrays

Hierarchy of Tensors

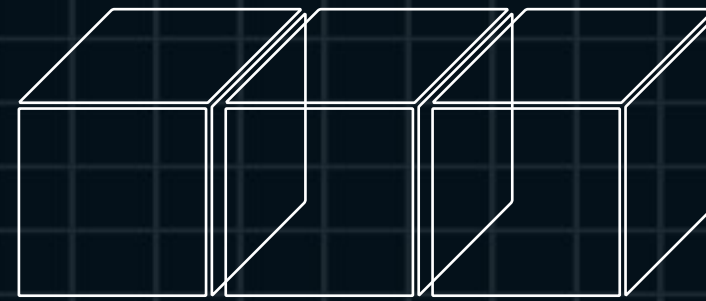


Lecture.2

Objects and ndarrays

- Tensors and ndarrays

Vector ndarrays(1st Tensors)



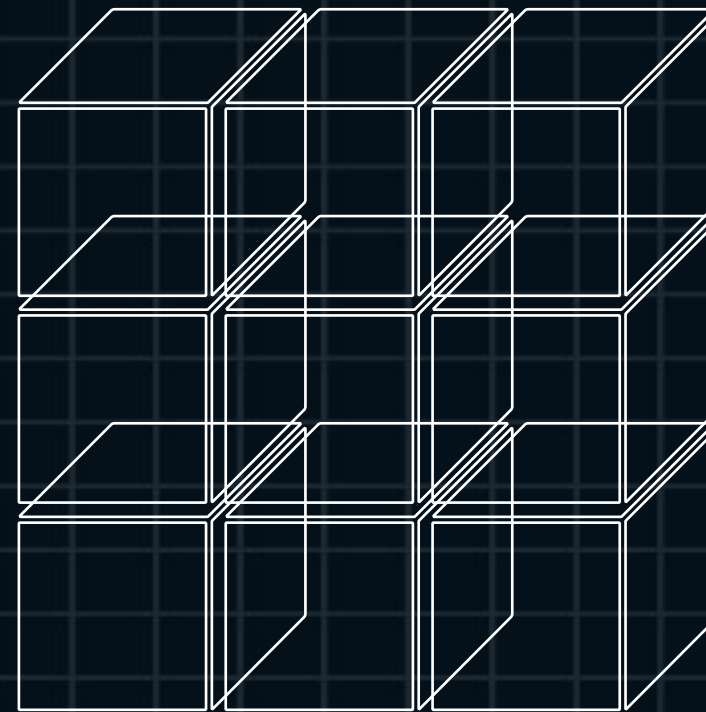
$(m,)$

Lecture.2

Objects and ndarrays

- Tensors and ndarrays

Matrix ndarrays(2nd Tensors)



(n, m)

(n, m)

Outer

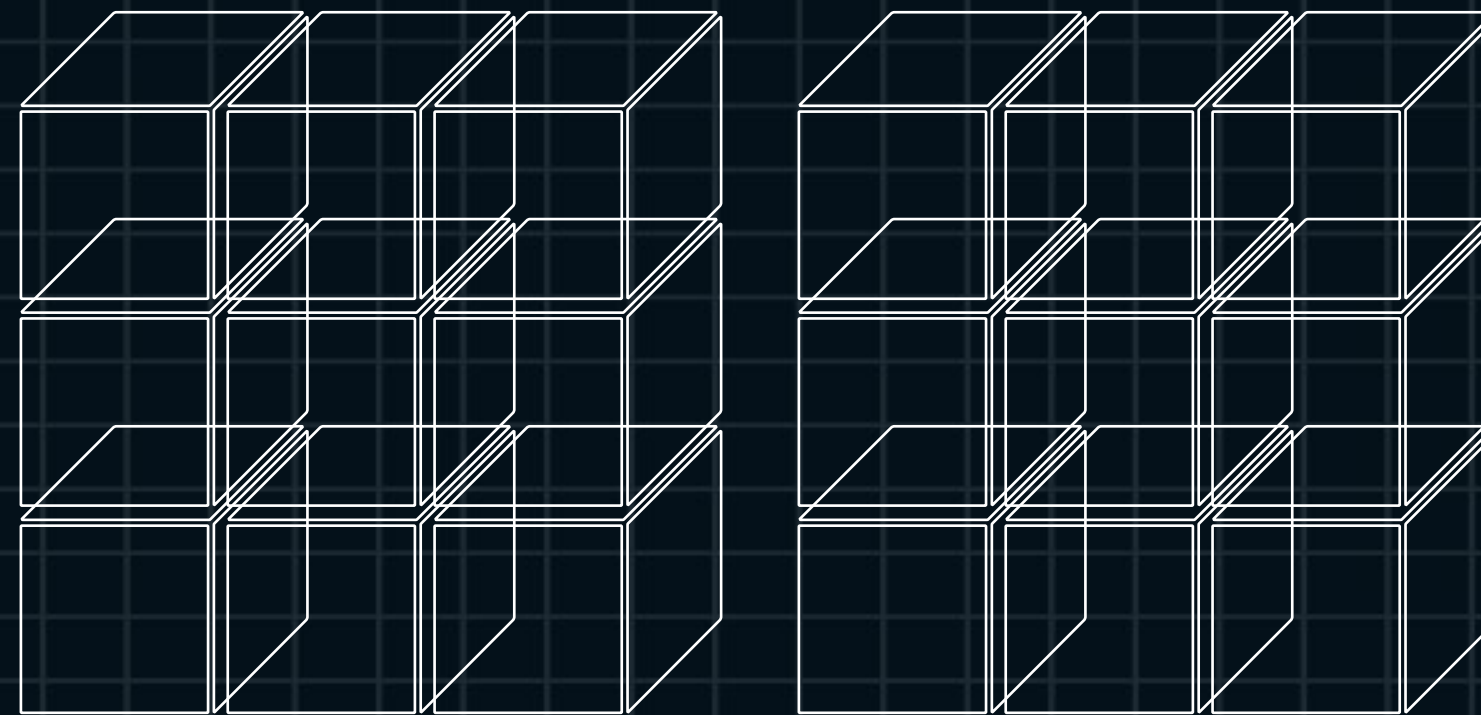
Inner

Lecture.2

Objects and ndarrays

- Tensors and ndarrays

Vector ndarrays(3rd Tensors)



(o, n, m)

(o, n, m)

Outermost

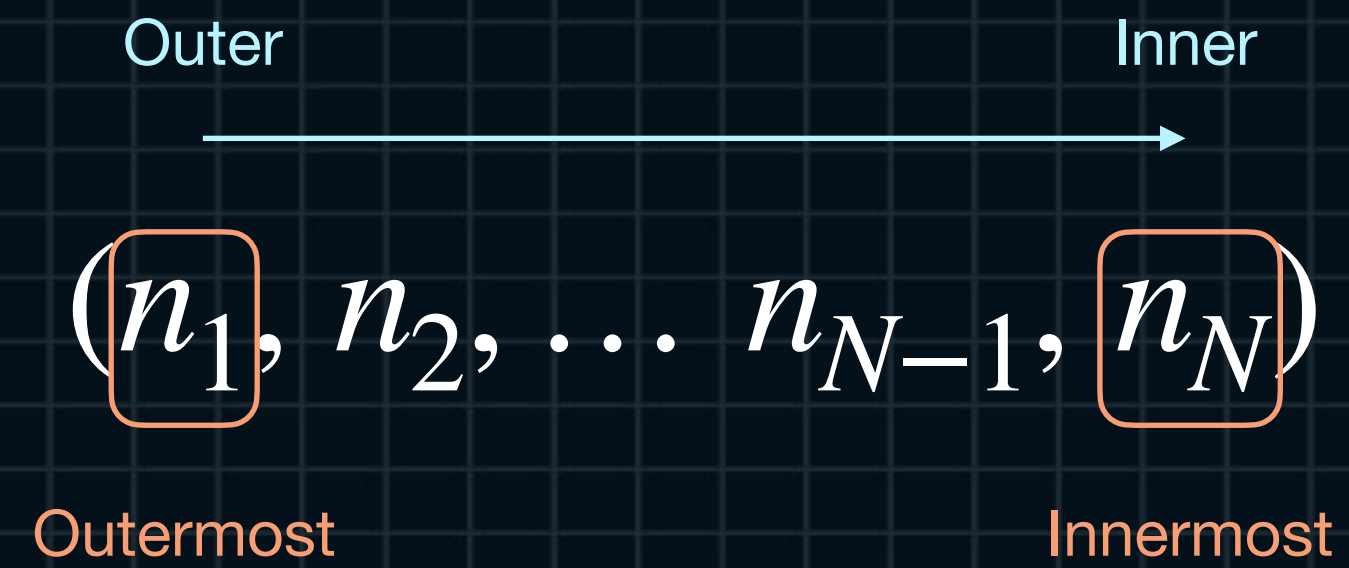
Innermost

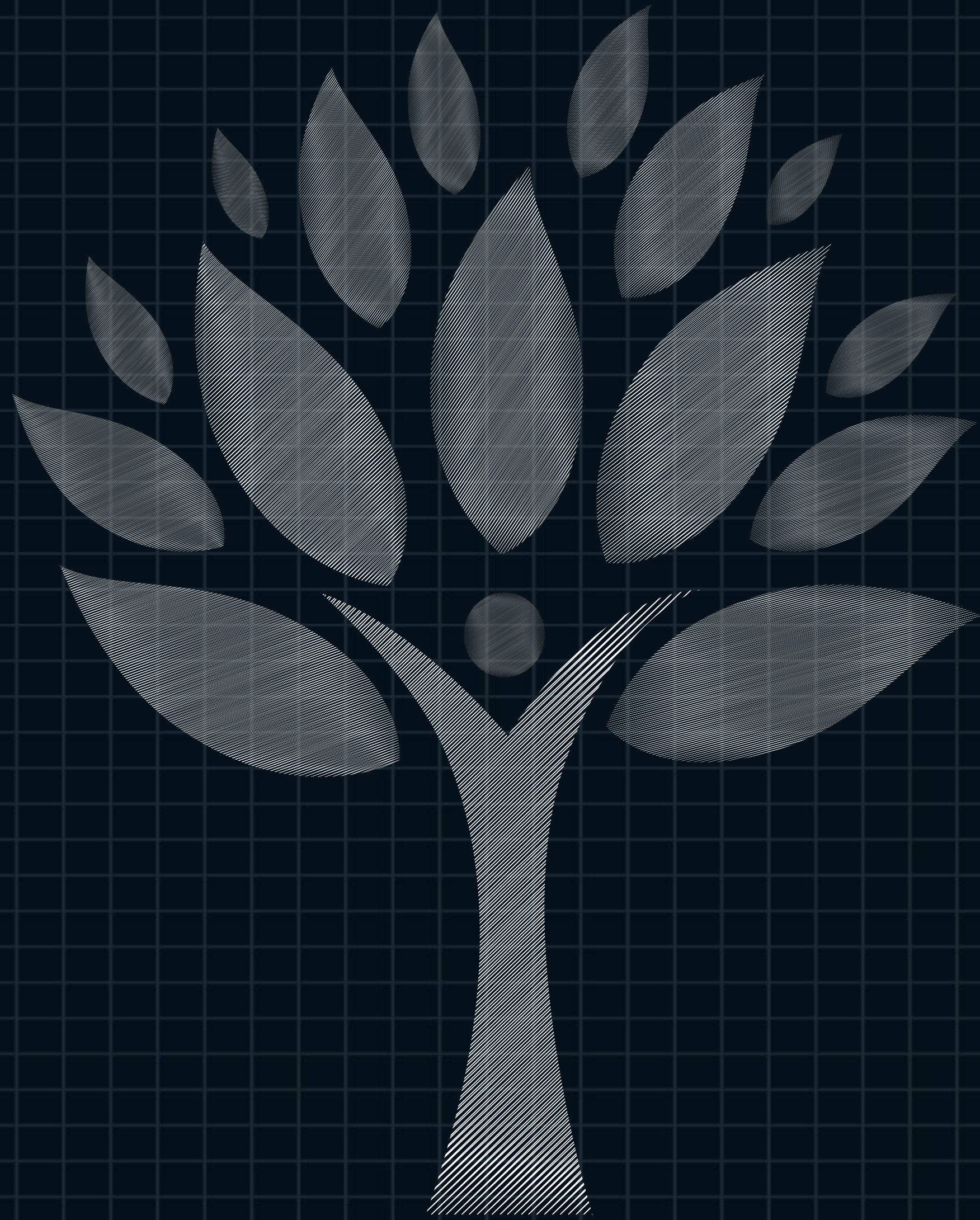
Lecture.2

Objects and ndarrays

- Tensors and ndarrays

n-th order Tensors





NumPy Master Class

Lecture.2 Objects and ndarrays