

Theano Tutorials

Session 2

Advanced usage

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Outline

- Manipulating symbolic expressions
- Debugging

Manipulating symbolic expressions

- The grad method
- Variable nodes
- Types
- Ops
- Apply nodes

The grad method

```
>>> x = T.scalar('x')
>>> y = 2. * x
>>> g = T.grad(y, x)
>>> from theano.printing import min_informative_str
>>> print min_informative_str(g)
```

- A. Elemwise{mul}
 - B. Elemwise{second,no_inplace}
 - C. Elemwise{mul,no_inplace}
 - D. TensorConstant{2.0}
 - E. x
 - F. TensorConstant{1.0}
- <D>

Holding variables constant

- Directly in the call to grad:
 - `consider_constant` allows you to specify a list of variables to hold constant
 - flexible, but easy to forget
- `block_gradient`
 - Not in Theano, in `pylearn2.utils`
 - Makes a constant out of any expression
 - Less flexible, but no risk of forgetting

Combining gradients from other sources

- Suppose $z(x) = f(g(x))$
- Suppose we want to split backprop into two steps:
 - backprop through f
 - backprop through g
- This can be more many reasons:
 - Maybe f is not a Theano function
 - Saving memory

known_grads

- Parameter of the grad method
- Specify a dictionary mapping variables to gradients that are already known
- Don't even need to specify a cost if a separating set is already known

Theano Variables

- A *Variable* is a theano expression
- Can come from T.scalar, T.matrix, etc.
- Can come from doing operations on other Variables
- Every Variable has a type field, identifying its Type
 - e.g. TensorType((True, False), 'float32')
- Variables can be thought of as *nodes* in a *graph*

Ops

- An Op is any class that describes a mathematical function of some variables
- Can call the op on some variables to get a new variable or variables
- An Op class can supply other forms of information about the function, such as its derivatives

Apply nodes

- The *Apply* class is a specific instance of an application of an Op
- Notable fields:
 - *op*: The Op to be applied
 - *inputs*: The Variables to be used as input
 - *outputs*: The Variables produced
- *Variable.owner* identifies the *Apply* that created the variable
- *Variable* and *Apply* instances are *nodes* and *owner/inputs/outputs* identify *edges* in a Theano graph

Exercises

- Work through the “01_symbolic” directory now

Debugging

- DEBUG_MODE
- compute_test_value
- min_informative_str
- DebugPrint
- Print
- Accessing the FunctionGraph
- WrapLinkers

compute_test_value

```
>>> from theano import config
>>> config.compute_test_value = 'raise'
>>> x = T.vector()
>>> import numpy as np
>>> x.tag.test_value = np.ones((2,))
>>> y = T.vector()
>>> y.tag.test_value = np.ones((3,))
>>> x + y
...
ValueError: Input dimension mis-match.
(input[0].shape[0] = 2, input[1].shape[0] = 3)
```

min_informative_str

```
>>> x = T.scalar()
>>> y = T.scalar()
>>> z = x + y
>>> z.name = 'z'
>>> a = 2. * z
>>> from theano.printing import min_informative_str
>>> print min_informative_str(a)
```

- A. Elemwise{mul,no_inplace}
- B. TensorConstant{2.0}
- C. z

debugprint

```
>>> from theano.printing import debugprint
>>> debugprint(a)
Elemwise{mul,no_inplace} [@A] "
|TensorConstant{2.0} [@B]
|Elemwise{add,no_inplace} [@C] 'z'
|<TensorType(float64, scalar)> [@D]
|<TensorType(float64, scalar)> [@E]
```

Print

```
x = theano.tensor.vector()  
x = theano.printing.Print('x', attrs=['min', 'max'])(x)
```


Accessing a function's fgraph

```
>>> x = T.scalar()
>>> y = x / x
>>> f = function([x], y)
>>> debugprint(f maker.fgraph.outputs[0])
DeepCopyOp [@A] "
|TensorConstant{1.0} [@B]
```

WrapLinkers

- In theano terms, a *Linker* is an object that drives the execution of the function. Goes through all Apply nodes and calls the Op's code on the inputs to generate the outputs
- You can write your own linker to wrap each of these individual calls with extra functionality
- Example uses:
 - Test that behavior is deterministic by having one Wraplinker that saves everything and one that reloads it and checks that the new values match.
 - Raise an error if any value is ever NaN

WrapLinkers continued

```
from theano.compile import Mode
```

```
def my_callback(i, node, fn):  
    # add any preprocessing here  
    fn()  
    # add any postprocessing here
```

```
class MyWrapLinker(Mode):  
    def __init__(self):  
        wrap_linker = theano.gof.WrapLinkerMany(  
            [theano.gof.OpWiseCLinker()],  
            [my_callback])  
        super(MyWrapLinker, self).__init__(wrap_linker,  
            optimizer='fast_run')
```

```
my_mode = MyWrapLinker()  
f = function(inputs, outputs, mode=my_mode)
```

Exercises

- Work through the “02_debugging” directory now