

C2_W3_Lab_2-graphs-for-complex-code

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1 Autograph: Graphs for complex code

In this ungraded lab, you'll go through some of the scenarios from the lesson `Creating graphs for complex code`.

1.1 Imports

```
[1]: try:
      # %tensorflow_version only exists in Colab.
      %tensorflow_version 2.x
    except Exception:
      pass

    import tensorflow as tf
```

As you saw in the lectures, seemingly simple functions can sometimes be difficult to write in graph mode. Fortunately, Autograph generates this complex graph code for us.

- Here is a function that does some multiplication and addition.

```
[2]: a = tf.Variable(1.0)
      b = tf.Variable(2.0)

      @tf.function
      def f(x,y):
          a.assign(y * b)
          b.assign_add(x * a)
          return a + b

      print(f(1.0, 2.0))

      print(tf.autograph.to_code(f.python_function))
```

```
tf.Tensor(10.0, shape=(), dtype=float32)
def tf__f(x, y):
    with ag__.FunctionScope('f', 'fscope',
ag__.ConversionOptions(recursive=True, user_requested=True,
```

```

optional_features=(), internal_convert_user_code=True)) as fscope:
    do_return = False
    retval_ = ag__.UndefinedReturnValue()
    ag__.converted_call(ag__.ld(a).assign, ((ag__.ld(y) * ag__.ld(b)),),
None, fscope)
    ag__.converted_call(ag__.ld(b).assign_add, ((ag__.ld(x) * ag__.ld(a)),),
None, fscope)
    try:
        do_return = True
        retval_ = (ag__.ld(a) + ag__.ld(b))
    except:
        do_return = False
        raise
    return fscope.ret(retval_, do_return)

```

- Here is a function that checks if the sign of a number is positive or not.

```

[3]: @tf.function
def sign(x):
    if x > 0:
        return 'Positive'
    else:
        return 'Negative or zero'

print("Sign = {}".format(sign(tf.constant(2))))
print("Sign = {}".format(sign(tf.constant(-2))))

print(tf.autograph.to_code(sign.python_function))

```

```

Sign = b'Positive'
Sign = b'Negative or zero'
def tf__sign(x):
    with ag__.FunctionScope('sign', 'fscope',
ag__.ConversionOptions(recursive=True, user_requested=True,
optional_features=(), internal_convert_user_code=True)) as fscope:
        do_return = False
        retval_ = ag__.UndefinedReturnValue()

        def get_state():
            return (retval_, do_return)

        def set_state(vars_):
            nonlocal retval_, do_return
            (retval_, do_return) = vars_

        def if_body():
            nonlocal retval_, do_return

```

```

        try:
            do_return = True
            retval_ = 'Positive'
        except:
            do_return = False
            raise

    def else_body():
        nonlocal retval_, do_return
        try:
            do_return = True
            retval_ = 'Negative or zero'
        except:
            do_return = False
            raise
    ag__.if_stmt((ag__.ld(x) > 0), if_body, else_body, get_state, set_state,
('retval_', 'do_return'), 2)
    return fscope.ret(retval_, do_return)

```

- Here is another function that includes a while loop.

```

[4]: @tf.function
def f(x):
    while tf.reduce_sum(x) > 1:
        tf.print(x)
        x = tf.tanh(x)
    return x

print(tf.autograph.to_code(f.python_function))

```

```

def tf__f(x):
    with ag__.FunctionScope('f', 'fscope',
ag__.ConversionOptions(recursive=True, user_requested=True,
optional_features=(), internal_convert_user_code=True)) as fscope:
        do_return = False
        retval_ = ag__.UndefinedReturnValue()

        def get_state():
            return (x,)

        def set_state(vars_):
            nonlocal x
            (x,) = vars_

        def loop_body():
            nonlocal x
            ag__.converted_call(ag__.ld(tf).print, (ag__.ld(x),), None, fscope)

```

```

        x = ag__.converted_call(ag__.ld(tf).tanh, (ag__.ld(x),), None,
fscope)

    def loop_test():
        return (ag__.converted_call(ag__.ld(tf).reduce_sum, (ag__.ld(x),),
None, fscope) > 1)
    ag__.while_stmt(loop_test, loop_body, get_state, set_state, ('x',), {})
    try:
        do_return = True
        retval_ = ag__.ld(x)
    except:
        do_return = False
        raise
    return fscope.ret(retval_, do_return)

```

- Here is a function that uses a for loop and an if statement.

```

[5]: @tf.function
def sum_even(items):
    s = 0
    for c in items:
        if c % 2 > 0:
            continue
        s += c
    return s

print(tf.autograph.to_code(sum_even.python_function))

```

```

def tf__sum_even(items):
    with ag__.FunctionScope('sum_even', 'fscope',
ag__.ConversionOptions(recursive=True, user_requested=True,
optional_features=(), internal_convert_user_code=True)) as fscope:
        do_return = False
        retval_ = ag__.UndefinedReturnValue()
        s = 0

        def get_state_2():
            return (s,)

        def set_state_2(vars_):
            nonlocal s
            (s,) = vars_

        def loop_body(itr):
            nonlocal s
            c = itr
            continue_ = False

```

```

def get_state():
    return (continue_,)

def set_state(vars_):
    nonlocal continue_
    (continue_,) = vars_

def if_body():
    nonlocal continue_
    continue_ = True

def else_body():
    nonlocal continue_
    pass
    ag__.if_stmt(((ag__.ld(c) % 2) > 0), if_body, else_body, get_state,
set_state, ('continue_',), 1)

def get_state_1():
    return (s,)

def set_state_1(vars_):
    nonlocal s
    (s,) = vars_

def if_body_1():
    nonlocal s
    s = ag__.ld(s)
    s += c

def else_body_1():
    nonlocal s
    pass
    ag__.if_stmt(ag__.not_(continue_), if_body_1, else_body_1,
get_state_1, set_state_1, ('s',), 1)
    continue_ = ag__.Undefined('continue_')
    c = ag__.Undefined('c')
    ag__.for_stmt(ag__.ld(items), None, loop_body, get_state_2, set_state_2,
('s',), {'iterate_names': 'c'})
    try:
        do_return = True
        retval_ = ag__.ld(s)
    except:
        do_return = False
        raise
    return fscope.ret(retval_, do_return)

```

1.2 Print statements

Tracing also behaves differently in graph mode. First, here is a function (not decorated with `@tf.function` yet) that prints the value of the input parameter. `f(2)` is called in a for loop 5 times, and then `f(3)` is called.

```
[6]: def f(x):  
      print("Traced with", x)  
  
      for i in range(5):  
          f(2)  
  
      f(3)
```

```
Traced with 2  
Traced with 2  
Traced with 2  
Traced with 2  
Traced with 2  
Traced with 3
```

If you were to decorate this function with `@tf.function` and run it, notice that the print statement only appears once for `f(2)` even though it is called in a loop.

```
[7]: @tf.function  
      def f(x):  
          print("Traced with", x)  
  
          for i in range(5):  
              f(2)  
  
          f(3)
```

```
Traced with 2  
Traced with 3
```

Now compare `print` to `tf.print`. - `tf.print` is graph aware and will run as expected in loops.

Try running the same code where `tf.print()` is added in addition to the regular `print`. - Note how `tf.print` behaves compared to `print` in graph mode.

```
[8]: @tf.function  
      def f(x):  
          print("Traced with", x)  
          # added tf.print  
          tf.print("Executed with", x)  
  
          for i in range(5):  
              f(2)
```

```
f(3)
```

```
Traced with 2
Executed with 2
Executed with 2
Executed with 2
Executed with 2
Executed with 2
Traced with 3
Executed with 3
```

1.3 Avoid defining variables inside the function

This function (not decorated yet) defines a tensor `v` and adds the input `x` to it.

Here, it runs fine.

```
[9]: def f(x):
      v = tf.Variable(1.0)
      v.assign_add(x)
      return v

      print(f(1))
```

```
<tf.Variable 'Variable:0' shape=() dtype=float32, numpy=2.0>
```

Now if you decorate the function with `@tf.function`.

The cell below will throw an error because `tf.Variable` is defined within the function. The graph mode function should only contain operations.

```
[10]: @tf.function
      def f(x):
          v = tf.Variable(1.0)
          v.assign_add(x)
          return v

      print(f(1))
```

```
↳
-----
ValueError                                Traceback (most recent call↳
↳last)

<ipython-input-10-5729586b3383> in <module>
      5     return v
      6
```

```

----> 7 print(f(1))

/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/
def_function.py in __call__(self, *args, **kwds)
    778         else:
    779             compiler = "nonXla"
--> 780             result = self._call(*args, **kwds)
    781
    782             new_tracing_count = self._get_tracing_count()

/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/
def_function.py in _call(self, *args, **kwds)
    838         # Lifting succeeded, so variables are initialized and we can
run the
    839         # stateless function.
--> 840         return self._stateless_fn(*args, **kwds)
    841     else:
    842         canon_args, canon_kwds = \

/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/function.
py in __call__(self, *args, **kwargs)
    2826         """Calls a graph function specialized to the inputs."""
    2827         with self._lock:
-> 2828             graph_function, args, kwargs = self.
maybe_define_function(args, kwargs)
    2829         return graph_function._filtered_call(args, kwargs) # pylint:
disable=protected-access
    2830

/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/function.
py in _maybe_define_function(self, args, kwargs)
    3211
    3212         self._function_cache.missed.add(call_context_key)
-> 3213         graph_function = self._create_graph_function(args, kwargs)
    3214         self._function_cache.primary[cache_key] = graph_function
    3215         return graph_function, args, kwargs

/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/function.
py in _create_graph_function(self, args, kwargs, override_flat_arg_shapes)
    3073         arg_names=arg_names,
    3074         override_flat_arg_shapes=override_flat_arg_shapes,
-> 3075         capture_by_value=self._capture_by_value),

```



```

3076         self._function_attributes,
3077         function_spec=self.function_spec,

/opt/conda/lib/python3.7/site-packages/tensorflow/python/framework/
↳func_graph.py in func_graph_from_py_func(name, python_func, args, kwargs,
↳signature, func_graph, autograph, autograph_options, add_control_dependencies,
↳arg_names, op_return_value, collections, capture_by_value,
↳override_flat_arg_shapes)
    984         _, original_func = tf_decorator.unwrap(python_func)
    985
--> 986         func_outputs = python_func(*func_args, **func_kwargs)
    987
    988         # invariant: `func_outputs` contains only Tensors,
↳CompositeTensors,

/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/
↳def_function.py in wrapped_fn(*args, **kwargs)
    598         # __wrapped__ allows AutoGraph to swap in a converted
↳function. We give
    599         # the function a weak reference to itself to avoid a
↳reference cycle.
--> 600         return weak_wrapped_fn().__wrapped__(*args, **kwargs)
    601         weak_wrapped_fn = weakref.ref(wrapped_fn)
    602

/opt/conda/lib/python3.7/site-packages/tensorflow/python/framework/
↳func_graph.py in wrapper(*args, **kwargs)
    971         except Exception as e: # pylint:disable=broad-except
    972             if hasattr(e, "ag_error_metadata"):
--> 973                 raise e.ag_error_metadata.to_exception(e)
    974             else:
    975                 raise

ValueError: in user code:

<ipython-input-10-5729586b3383>:3 f *
    v = tf.Variable(1.0)
/opt/conda/lib/python3.7/site-packages/tensorflow/python/ops/variables.
↳py:262 __call__ **
    return cls._variable_v2_call(*args, **kwargs)
/opt/conda/lib/python3.7/site-packages/tensorflow/python/ops/variables.
↳py:256 _variable_v2_call
    shape=shape)

```

```

/opt/conda/lib/python3.7/site-packages/tensorflow/python/ops/variables.
↳py:67 getter
    return captured_getter(captured_previous, **kwargs)
/opt/conda/lib/python3.7/site-packages/tensorflow/python/eager/
↳def_function.py:702 invalid_creator_scope
    "tf.function-decorated function tried to create "

ValueError: tf.function-decorated function tried to create variables on
↳non-first call.

```

To get around the error above, simply move `v = tf.Variable(1.0)` to the top of the cell before the `@tf.function` decorator.

```

[11]: # define the variables outside of the decorated function
v = tf.Variable(1.0)

@tf.function
def f(x):
    return v.assign_add(x)

print(f(5))

```

```
tf.Tensor(6.0, shape=(), dtype=float32)
```