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TORCH.FX

Overview

This feature is experimental and its stability is not currently guaranteed. Proceed at your own risk

FX is a toolkit for capturing and transforming functional PyTorch programs. It consists of GraphModule and a corresponding intermediate representation (IR). When GraphModule is constructed with an nn.Module instance as its argument, GraphModule will trace through the computation of that Module's forward method symbolically and record those operations in the FX intermediate representation.

```
import torch
import torch.fx

class MyModule(torch.nn.Module):
    def __init__(self):
        super().__init__()
        self.param = torch.nn.Parameter(torch.rand(3, 4))
        self.linear = torch.nn.Linear(4, 5)

    def forward(self, x):
        return torch.topk(torch.sum(self.linear(x + self.linear.weight).relu(), dim=-1), 3)

m = MyModule()
gm = torch.fx.symbolic_trace(m)
```

The Intermediate Representation centers around a 5-opcode format:

```
print(gm.graph)
```

```
graph(x):
  %linear_weight : [#users=1] = self.linear.weight
  %add_1 : [#users=1] = call_function[target=<built-in function add>](args = (%x, %linear_weight), kwargs = {})
  %linear_1 : [#users=1] = call_module[target=linear](args = (%add_1,), kwargs = {})
  %relu_1 : [#users=1] = call_method[target=relu](args = (%linear_1,), kwargs = {})
  %sum_1 : [#users=1] = call_function[target=<built-in method sum of type object at 0x7ff2da9dc300>](args = (%relu_1,), kwargs = {dim:
-1})
  %topk_1 : [#users=1] = call_function[target=<built-in method topk of type object at 0x7ff2da9dc300>](args = (%sum_1, 3), kwargs = {})
  return topk_1
```

The Nop semantics are as follows:

- `placeholder` represents a function input. The `name` attribute specifies the name this value will take on. `target` is similarly the name of the argument. `args` holds either: 1) nothing, or 2) a single argument denoting the default parameter of the function input. `kwargs` is on't-care. Placeholders correspond to the function parameters (e.g. `x`) in the graph printout.
- `getattr` retrieves a parameter from the module hierarchy. `name` is similarly the name the result of the fetch is assigned to. `target` is the fully-qualified name of the parameter's position in the module hierarchy. `args` and `kwargs` are on't-care
- `call_function` applies a free function to some values. `name` is similarly the name of the value to assign to. `target` is the function to be applied. `args` and `kwargs` represent the arguments to the function, following the Python calling convention
- `call_module` applies a module in the module hierarchy's `forward()` method to given arguments. `name` is as previous. `target` is the fully-qualified name of the module in the module hierarchy to call. `args` and `kwargs` represent the arguments to invoke the module on, *including the self argument*.
- `call_method` calls a method on a value. `name` is as similar. `target` is the string name of the method to apply to the `self` argument. `args` and `kwargs` represent the arguments to invoke the module on, *including the self argument*
- `output` contains the output of the trace function in its `args[0]` attribute. This corresponds to the "return" statement in the Graph printout.

GraphModule automatically generates Python code for the operations it symbolically operates:

```
print(gm.code)
```

```

import torch
def forward(self, x):
    linear_weight = self.linear.weight
    add_1 = x + linear_weight
    x = linear_weight = None
    linear_1 = self.linear(add_1)
    add_1 = None
    relu_1 = linear_1.relu()
    linear_1 = None
    sum_1 = torch.sum(relu_1, dim = -1)
    relu_1 = None
    topk_1 = torch.topk(sum_1, 3)
    sum_1 = None
    return topk_1
    topk_1 = None

```

Because this code is valid PyTorch code, the resulting `GraphModule` can be used in any context another `nn.Module` can be used, including in TorchScript tracing/compilation.

API Reference

`torch.fx.symbolic_trace(root: Union[torch.nn.modules.module.Module, Callable])` → `torch.fx.graph_module.GraphModule` [SOURCE]

Symbolic tracing API

Given an `nn.Module` or function instance `root`, this function will return a `GraphModule` constructed by recording operations seen while tracing through `root`.

Parameters

root (`Union[torch.nn.Module, Callable]`) – Module or function to be traced and converted into a Graph representation.

Returns

a Module created from the recorded operations from `root`.

Return type

`GraphModule`

CLASS `torch.fx.GraphModule(root: Union[torch.nn.modules.module.Module, Dict[str, Any]], graph: torch.fx.graph.Graph)` [SOURCE]

`GraphModule` is an `nn.Module` generated from an `fx.Graph`. `GraphModule` has a `graph` attribute, as well as `code` and `forward` attributes generated from that `graph`.

• WARNING

When `graph` is reassigned, `code` and `forward` will be automatically regenerated. However, if you edit the contents of the `graph` without reassigning the `graph` attribute itself, you must call `recompile()` to update the generated code.

`__init__(root: Union[torch.nn.modules.module.Module, Dict[str, Any]], graph: torch.fx.graph.Graph)` [SOURCE]

Construct a `GraphModule`.

Parameters

- root** (`Union[torch.nn.Module, Dict[str, Any]]`) – `root` can either be an `nn.Module` instance or a Dict mapping strings to any attribute type. In the case that `root` is a Module, any references to Module-level objects (via qualified name) in the Graph's Nodes' `target` field will be copied over from the respective place within `root`'s Module hierarchy into the `GraphModule`'s module hierarchy. In the case that `root` is a Dict, the qualified name found in a Node's `target` will be looked up directly in the Dict's keys. The object mapped to by the Dict will be copied over into the appropriate place within the `GraphModule`'s module hierarchy.
- graph** (`Graph`) – `graph` contains the nodes this `GraphModule` should use for code generation

PROPERTY `code`

Return the Python code generated from the `Graph` underlying this `GraphModule`.

PROPERTY `graph`

Return the `Graph` underlying this `GraphModule`

`recompile()` → None [SOURCE]

Recompile this `GraphModule` from its `graph` attribute. This should be called after editing the contained `graph`, otherwise the generated code of this `GraphModule` will be out of date.

CLASS `torch.fx.Graph` [SOURCE]

`Graph` is the main data structure used in the FX Intermediate Representation. It consists of a series of `Node`s, each representing callsites (or other syntactic constructs). The list of `Node`s, taken together, constitute a valid Python function.

For example, the following code

```

import torch
import torch.fx

class MyModule(torch.nn.Module):
    def __init__(self):
        super().__init__()
        self.param = torch.nn.Parameter(torch.rand(3, 4))
        self.linear = torch.nn.Linear(4, 5)

    def forward(self, x):
        return torch.topk(torch.sum(self.linear(x + self.linear.weight).relu(), dim=-1), 3)

m = MyModule()
gm = torch.fx.symbolic_trace(m)

```

Will produce the following Graph:

```
print(gm.graph)
```

```

graph(x):
  %linear_weight : [#users=1] = self.linear.weight
  %add_1 : [#users=1] = call_function[target=<built-in function add>](args = (%x, %linear_weight), kwargs = {})
  %linear_1 : [#users=1] = call_module[target=linear](args = (%add_1,), kwargs = {})
  %relu_1 : [#users=1] = call_method[target=relu](args = (%linear_1,), kwargs = {})
  %sum_1 : [#users=1] = call_function[target=<built-in method sum of type object at 0x7ff2da9dc300>](args = (%relu_1,), kwargs =
{dim: -1})
  %topk_1 : [#users=1] = call_function[target=<built-in method topk of type object at 0x7ff2da9dc300>](args = (%sum_1, 3), kwargs =
{})
  return topk_1

```

The Node semantics are as follows:

- `placeholder` represents a function input. The `name` attribute specifies the name this value will take on. `target` is similarly the name of the argument. `args` holds either: 1) nothing, or 2) a single argument denoting the default parameter of the function input. `kwargs` is on't-care. Placeholders correspond to the function parameters (e.g. `x`) in the graph printout.
- `get_attr` retrieves a parameter from the module hierarchy. `name` is similarly the name the result of the fetch is assigned to. `target` is the fully-qualified name of the parameter's position in the module hierarchy. `args` and `kwargs` are on't-care
- `call_function` applies a free function to some values. `name` is similarly the name of the value to assign to. `target` is the function to be applied. `args` and `kwargs` represent the arguments to the function, following the Python calling convention
- `call_module` applies a module in the module hierarchy's `forward()` method to given arguments. `name` is as previous. `target` is the fully-qualified name of the module in the module hierarchy to call. `args` and `kwargs` represent the arguments to invoke the module on, *including the self argument*.
- `call_method` calls a method on a value. `name` is as similar. `target` is the string name of the method to apply to the `self` argument. `args` and `kwargs` represent the arguments to invoke the module on, *including the self argument*
- `output` contains the output of the trace function in its `args[0]` attribute. This corresponds to the "return" statement in the Graph printout.

```
__init__()
```

[SO RCE]

Construct an empty Graph.

```
call_function(the_function: Callable[[...], Any], args: Optional[Tuple[Argument, ...]] = None, kwargs: Optional[Dict[str, Argument]] = None, type_expr: Optional[Any] = None) → torch.fx.node.No e
```

[SO RCE]

Insert a `call_function` Node into the `Graph`. A `call_function` node represents a call to a Python callable, specified by `the_function`. `the_function` can be

Parameters

- **the_function** (`Callable[., Any]`) – The function to be called. Can be any PyTorch operator, Python function, or member of the `builtins` or `operator` namespaces.
- **args** (`Optional[Tuple[Argument, ...]]`) – The positional arguments to be passed to the called function.
- **kwargs** (`Optional[Dict[str, Argument]]`) – The keyword arguments to be passed to the called function
- **type_expr** (`Optional[Any]`) – an optional type annotation representing the Python type the output of this node will have.

Returns

The newly created and inserted `call_function` node.

• NOTE

The same insertion point and type expression rules apply for this method as `Graph.create_node()`.

```
call_method(method_name: str, args: Optional[Tuple[Argument, ...]] = None, kwargs: Optional[Dict[str, Argument]] = None, type_expr: Optional[Any] = None) → torch.fx.node.No e
```

[SO RCE]

Insert a `call_method` Node into the `Graph`. A `call_method` node represents a call to a given method on the 0th element of `args`.

Parameters

- **method_name** (*str*) – The name of the method to apply to the self argument. For example, if `args[0]` is a `Node` representing a `Tensor`, then to call `relu()` on that `Tensor`, pass `relu` to `method_name`.
- **args** (*Optional[Tuple[Argument, ...]]*) – The positional arguments to be passed to the called method. Note that this *should* include a `self` argument.
- **kwargs** (*Optional[Dict[str, Argument]]*) – The keyword arguments to be passed to the called method.
- **type_expr** (*Optional[Any]*) – an optional type annotation representing the Python type the output of this node will have.

Returns

The newly-created and inserted `call_method` node.

• NOTE

The same insertion point and type expression rules apply for this method as `Graph.create_node()`.

```
call_module(module_name: str, args: Optional[Tuple[Argument, ...]] = None, kwargs: Optional[Dict[str, Argument]] = None, type_expr: Optional[Any] = None) → torch.fx.node.Node
```

[SO RCE]

Insert a `call_module` Node into the `Graph`. A `call_module` node represents a call to the `forward()` function of a `Module` in the `Module` hierarchy.

Parameters

- **module_name** (*str*) – The qualified name of the `Module` in the `Module` hierarchy to be called. For example, if the `trace` `Module` has a submodule name `foo`, which has a submodule name `bar`, the qualified name `foo.bar` should be passed as `module_name` to call that module.
- **args** (*Optional[Tuple[Argument, ...]]*) – The positional arguments to be passed to the called method. Note that this should *not* include a `self` argument.
- **kwargs** (*Optional[Dict[str, Argument]]*) – The keyword arguments to be passed to the called method.
- **type_expr** (*Optional[Any]*) – an optional type annotation representing the Python type the output of this node will have.

Returns

The newly-created and inserted `call_module` node.

• NOTE

The same insertion point and type expression rules apply for this method as `Graph.create_node()`.

```
create_node(op: str, target: Union[Callable[[...], Any], str], args: Optional[Tuple[Argument, ...]] = None, kwargs: Optional[Dict[str, Argument]] = None, name: Optional[str] = None, type_expr: Optional[Any] = None) → torch.fx.node.Node
```

[SO RCE]

Create a `Node` and add it to the `Graph` at the current insert-point. Note that the current insert-point can be set via `Graph.inserting_before()` or `Graph.inserting_after()`.

Parameters

- **op** (*str*) – the opcode for this Node. One of 'call_function', 'call_method', 'get_attr', 'call_module', 'placeholder', or 'output'. The semantics of these opcodes are described in the `Graph` docstring.
- **args** (*Optional[Tuple[Argument, ...]]*) – is a tuple of arguments to this node.
- **kwargs** (*Optional[Dict[str, Argument]]*) – the kwargs of this Node.
- **name** (*Optional[str]*) – an optional string name for the `Node`. This will influence the name of the value assigned to in the Python generated code.
- **type_expr** (*Optional[Any]*) – an optional type annotation representing the Python type the output of this node will have.

Returns

The newly-created and inserted node.

```
erase_node(to_erase: torch.fx.node.Node) → None
```

[SO RCE]

Erases a `Node` from the `Graph`. Throws an exception if there are still users of that node in the `Graph`.

Parameters

to_erase (*Node*) – The `Node` to erase from the `Graph`.

```
get_attr(qualified_name: str, type_expr: Optional[Any] = None) → torch.fx.node.Node
```

[SO RCE]

Insert a `get_attr` node into the `Graph`. A `get_attr` Node represents the fetch of an attribute from the `Module` hierarchy.

Parameters

- **qualified_name** (*str*) – the fully-qualified name of the attribute to be retrieved. For example, if the `trace` `Module` has a submodule name `foo`, which has a submodule name `bar`, which has an attribute name `baz`, the qualified name `foo.bar.baz` should be passed as `qualified_name`.
- **type_expr** (*Optional[Any]*) – an optional type annotation representing the Python type the output of this node will have.

Returns

The newly-created and inserted `get_attr` node.

• NOTE

The same insertion point and type expression rules apply for this method as `Graph.create_node`.

`graph_copy(g: torch.fx.graph.Graph, val_map: Dict[torch.fx.node.Node, torch.fx.node.Node]) → Union[Tuple[Any, ...], List[Any], Dict[str, Any], slice, None, str, int, float, bool, torch.dtype, torch.Tensor, None]` [SO RCE]

Copy all nodes from a given graph into `self`.

Parameters

- **g** (`Graph`) – The source graph from which to copy nodes.
- **val_map** (`Dict[Node, Node]`) – a dictionary that will be populated with a mapping from nodes in `g` to nodes in `self`. Note that `val_map` can be passed in with values in it already to override copying of certain values.

Returns

The value in `self` that is now equivalent to the output value in `g`, if `g` has an `output` node. `None` otherwise.

`inserting_after(n: Optional[torch.fx.node.Node] = None)` [SO RCE]

Set the point at which `create_node` and companion methods will insert into the graph. When used within a ‘with’ statement, this will temporarily set the insert point and then restore it when the with statement exits:

```
with g.inserting_after(n):
    ... # inserting after node n
    ... # insert point restored to what it was previously
g.inserting_after(n) # set the insert point permanently
```

Parameters

n (`Optional[Node]`) – The node before which to insert. If `None` this will insert after the beginning of the entire graph.

Returns

A resource manager that will restore the insert point on `__exit__`.

`inserting_before(n: Optional[torch.fx.node.Node] = None)` [SO RCE]

Set the point at which `create_node` and companion methods will insert into the graph. When used within a ‘with’ statement, this will temporarily set the insert point and then restore it when the with statement exits:

```
with g.inserting_before(n):
    ... # inserting before node n
    ... # insert point restored to what it was previously
g.inserting_before(n) # set the insert point permanently
```

Parameters

n (`Optional[Node]`) – The node before which to insert. If `None` this will insert before the beginning of the entire graph.

Returns

A resource manager that will restore the insert point on `__exit__`.

`lint(root: Optional[torch.nn.modules.module.Module] = None)` [SO RCE]

Runs various checks on this Graph to make sure it is well-formed. In particular:

- Checks nodes have correct ownership (owned by this graph)
- Checks nodes appear in topological order
- If `root` is provided, checks that targets exist in `root`

Parameters

root (`Optional[torch.nn.Module]`) – The root module with which to check for targets. This is equivalent to the `root` argument that is passed when constructing a `GraphModule`.

`node_copy(node: torch.fx.node.Node, arg_transform: Callable[[torch.fx.node.Node], Argument] = <function Graph.<lambda>>)` [SO RCE]
`→ torch.fx.node.Node`

Copy a node from one graph into another. `arg_transform` needs to transform arguments from the graph of node to the graph of self. Example:

```
# Copying all the nodes in 'g' into 'new_graph'
g : torch.fx.Graph = ...
new_graph = torch.fx.graph()
value_remap = {}
for node in g.nodes:
    value_remap[node] = new_graph.node_copy(node, lambda n : value_remap[n])
```

Parameters

- **node** (*Node*) – The node to copy into `self`.
- **arg_transform** (*Callable[[Node], Argument]*) – A function that transforms `Node` arguments in node's `args` and `kwargs` into the equivalent argument in `self`. In the simplest case, this should retrieve a value out of a table mapping Nodes in the original graph to `self`.

PROPERTY `nodes`

Get the list of Nodes that constitute this Graph.

Note that this `Node` list representation is a doubly-linked list. Mutations during iteration (e.g. delete a Node, add a Node) are safe.

Returns

A doubly-linked list of Nodes. Note that `reversed` can be called on this list to switch iteration order.

`output(result: Union[Tuple[Any, ...], List[Any], Dict[str, Any], slice, Node, str, int, float, bool, torch.dtype, torch.Tensor, None], type_expr: Optional[Any] = None)` [SO RCE]

Insert an `output` Node into the `Graph`. An `output` node represents a `return` statement in Python code. `result` is the value that should be returned.

Parameters

- **result** (*Argument*) – The value to be returned.
- **type_expr** (*Optional[Any]*) – an optional type annotation representing the Python type the output of this node will have.

• NOTE

The same insertion point and type expression rules apply for this method as `Graph.create_node`.

`placeholder(name: str, type_expr: Optional[Any] = None) → torch.fx.node.No e` [SO RCE]

Insert a `placeholder` node into the `Graph`. A `placeholder` represents a function input.

Parameters

- **name** (*str*) – A name for the input value. This corresponds to the name of the positional argument to the function this `Graph` represents.
- **type_expr** (*Optional[Any]*) – an optional type annotation representing the Python type the output of this node will have. This is needed in some cases for proper code generation (e.g. when the function is used subsequently in TorchScript compilation).

• NOTE

The same insertion point and type expression rules apply for this method as `Graph.create_node`.

`python_code(root_module: str) → str` [SO RCE]

Turn this `Graph` into valid Python code.

Parameters

root_module (*str*) – The name of the root module on which to look-up qualified name targets. This is usually 'self'.

Returns

The string source code generated from this `Graph`.

CLASS `torch.fx.Node(graph: Graph, name: str, op: str, target: Union[Callable[...], Any], str], args: Tuple[Union[Tuple[Any, ...], List[Any], Dict[str, Any], slice, Node, str, int, float, bool, torch.dtype, torch.Tensor, None], ...], kwargs: Dict[str, Union[Tuple[Any, ...], List[Any], Dict[str, Any], slice, Node, str, int, float, bool, torch.dtype, torch.Tensor, None]], type: Optional[Any] = None)` [SO RCE]

PROPERTY `all_input_nodes`

Return all Nodes that are inputs to this Node. This is equivalent to iterating over `args` and `kwargs` and only collecting the values that are Nodes.

`append(x: torch.fx.node.No e)` [SO RCE]

Insert `x` after this node in the list of nodes in the graph. Equivalent to `self.next.prepend(x)`

Parameters

x (*Node*) – The node to put after this node. Must be a member of the same graph.

PROPERTY `args`

Return the tuple of arguments to this Node. The interpretation of arguments depends on the node's opcode. See the `fx.Graph` docstring for more information.

PROPERTY `kwargs`

Return the dict of kwargs to this Node. The interpretation of arguments depends on the node's opcode. See the `fx.Graph` docstring for more information.

PROPERTY `next`

Get the next node in the linked list

prepend(*x: torch.fx.node.Node*)

[SO RCE]

Insert *x* before this node in the list of nodes in the graph.

Before: `p -> self`

`x -> x -> ax`

After: `p -> x -> self`

`x -> ax`

Parameters

x (*Node*) – The node to put before this node. Must be a member of the same graph.

PROPERTY `prev`

Get the previous node in the linked list

replace_all_uses_with(*replace_with: torch.fx.node.Node*) → List[torch.fx.node.Node]

[SO RCE]

Replace all uses of `self` in the Graph with the Node `replace_with`. Returns the list of nodes on which this change was made.

CLASS `torch.fx.Tracer`

[SO RCE]

`Tracer` is the class that implements the symbolic tracing functionality of `torch.fx.symbolic_trace`. A call to `symbolic_trace(m)` is equivalent to `Tracer().trace(m)`.

Tracer can be subclassed to override various behaviors of the tracing process. The different behaviors that can be overridden are described in the docstrings of the methods on this class.

call_module(*m: torch.nn.modules.module.Module, forward: Callable[[...], Any], args, kwargs*)

[SO RCE]

Method that specifies the behavior of this `Tracer` when it encounters a call to an `nn.Module` instance.

By default, the behavior is to check if the called module is a leaf module via `is_leaf_module`. If it is, emit a `call_module` node referring to `m` in the `Graph`. Otherwise, call the `Module` normally, tracing through the operations in its `forward` function.

This method can be overridden to—for example—create nested `GraphModule`s, or any other behavior you would want while tracing across `Module` boundaries.

create_arg(*a: Any*) → Union[Tuple[Any, ...], List[Any], Dict[str, Any], slice, Node, str, int, float, bool, torch.dtype, torch.Tensor, None]

[SO RCE]

A method to specify the behavior of tracing when preparing values to be used as arguments to nodes in the `Graph`.

By default, the behavior includes: - Iterate through collection types (e.g. tuple, list, dict) and recursively

call `create_args` on the elements.

- Given a Proxy object, return a reference to the underlying IR `Node`
- Given a non-Proxy Tensor object, emit IR for various cases:
 - For a Parameter, emit a `get_attr` node referring to that Parameter
 - For a non-Parameter Tensor, store the Tensor away in a special attribute referring to that attribute.

This method can be overridden to support more types.

create_args_for_root(*root_fn, is_module*)

[SO RCE]

Create `placeholder` nodes corresponding to the signature of the `root` Module. This method introspects `root`'s signature and emits those nodes accordingly, also supporting `*args` and `**kwargs`.

is_leaf_module(*m: torch.nn.modules.module.Module, module_qualified_name: str*) → bool

[SO RCE]

A method to specify whether a given `nn.Module` is a “leaf” module.

Leaf modules are the atomic units that appear in the IR, referenced by `call_module` calls. By default, Modules in the PyTorch standard library namespace (`torch.nn`) are leaf modules. All other modules are traced through and their constituent ops are recorded, unless specified otherwise via this parameter.

Argument: The module itself or the qualified name. The path to root of this module. For example,

Args: `module` - The module whose qualified name is the path to root or this module. For example,

if you have a module hierarchy where submodule `foo` contains submodule `bar`, which contains submodule `baz`, that module will appear with the qualified name `foo.bar.baz` here.

`path_of_module(mod) → str`

[SOURCE]

Helper method to find the qualified name of `mod` in the Module hierarchy of `root`. For example, if `root` has a submodule name `foo`, which has a submodule name `bar`, passing `bar` into this function will return the string “foo.bar”.

`trace(root: Union[torch.nn.modules.module.Module, Callable]) → torch.fx.graph.Graph`

[SOURCE]

Trace `root` and return the corresponding FX Graph representation. `root` can either be an `nn.Module` instance or a Python callable.

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