C++ Debugging in VSCode

PyTorch has good support for C++ debugging. This guide walks you through how to utilize it and integrate it with VSCode.

Why would you need this?

This guide is for contributors to PyTorch or PyTorch/XLA who need to touch the C++ internals to build features like custom C++ operations.

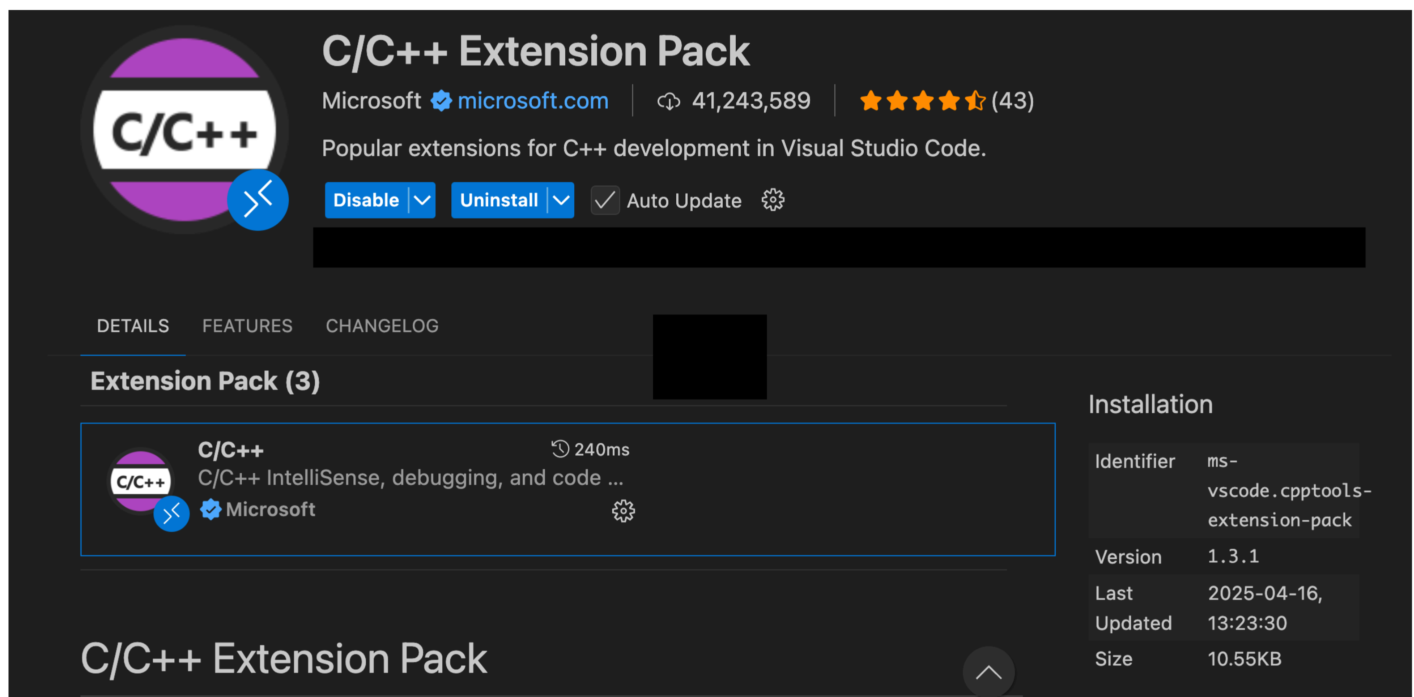
Install GDB: The GNU Project Debugger

The official instructions are here but if you are in a conda environment, you can install it as

```
conda install -c conda-forge gdb
```

VSCode Configuration

Integrating with VSCode will require installing the C/C++ Extension Pack, published by Microsoft. Search in the Extensions tab of VSCode with the identifier `ms-vscode.cpptools-extension-pack`.



Next, you'll need to create a `launch.json` in the `pytorch/.vscode` folder. Here is a sample file to start from. You'll need to adjust the file paths to match your specific installation.

```
{
    "version": "0.2.0",
    "configurations": [
        {
            "name": "GDB a python interpreter",
            "type": "cppdbg",
            "request": "launch",
            "program": "/home/USERNAME/miniconda3/envs/torch310/bin/python",
// Replace with your executable's path
            "args": [],
            "cwd": "${workspaceFolder}",
            "environment": [],
            "externalConsole": false,
            "MIMode": "gdb",
            "setupCommands": [
                {
                    "description": "Enable pretty-printing for gdb",
                    "text": "-enable-pretty-printing",
                    "ignoreFailures": true
                },
                {
                    "description": "Set Disassembly flavor to Intel",
                    "text": "-gdb-set disassembly-flavor intel",
                    "ignoreFailures": true
                }
            ],
            // "preLaunchTask": "C/C++: g++ build active file",
            "miDebuggerPath":
"/home/USERNAME/miniconda3/envs/torch310/bin/gdb" // Replace with your gdb
location
        }
    ]
 }
```

Building with Debugging Symbols

Looking into `setup.py`, we see

```
# Environment variables you are probably interested in:
#
#   DEBUG
#     build with -O0 and -g (debug symbols)
#
#   REL_WITH_DEB_INFO
#     build with optimizations and -g (debug symbols)
#
```

```
#   USE_CUSTOM_DEBINFO="path/to/file1.cpp;path/to/file2.cpp"
#     build with debug info only for specified files
```

source

Setting `DEBUG` will result in a very slow binary, since every single file will be unoptimized (`-O0`) and built with debugging symbols.

In practice, you'll want to set the `USE_CUSTOM_DEBINFO` instead.

The challenge becomes knowing which files to build with debugging symbols. A common issue will be debugging a file, then realizing you want to look at data structures or another function call in a file that's not built with debugging symbols.

Your basic flow as you get started is:

1. Identify the source file you want to debug.
2. Build that file with debugger symbols
3. Start a debugger session with a breakpoint. You'll discover additional files you want to debug.
4. Add those files to the `USE_CUSTOM_DEBINFO`
5. Rebuild those files
6. Rebuild with a command similar to `USE_CUSTOM_DEBINFO="aten/src/ATen/native/Linear.cpp;newfile.cpp" python setup.py develop`
7. Start your debugger session again.

Again, the key line environment variable to set is `USE_CUSTOM_DEBINFO`.

Ensuring your file is built

In our experience, you'll need to do a full clean and rebuild each time.

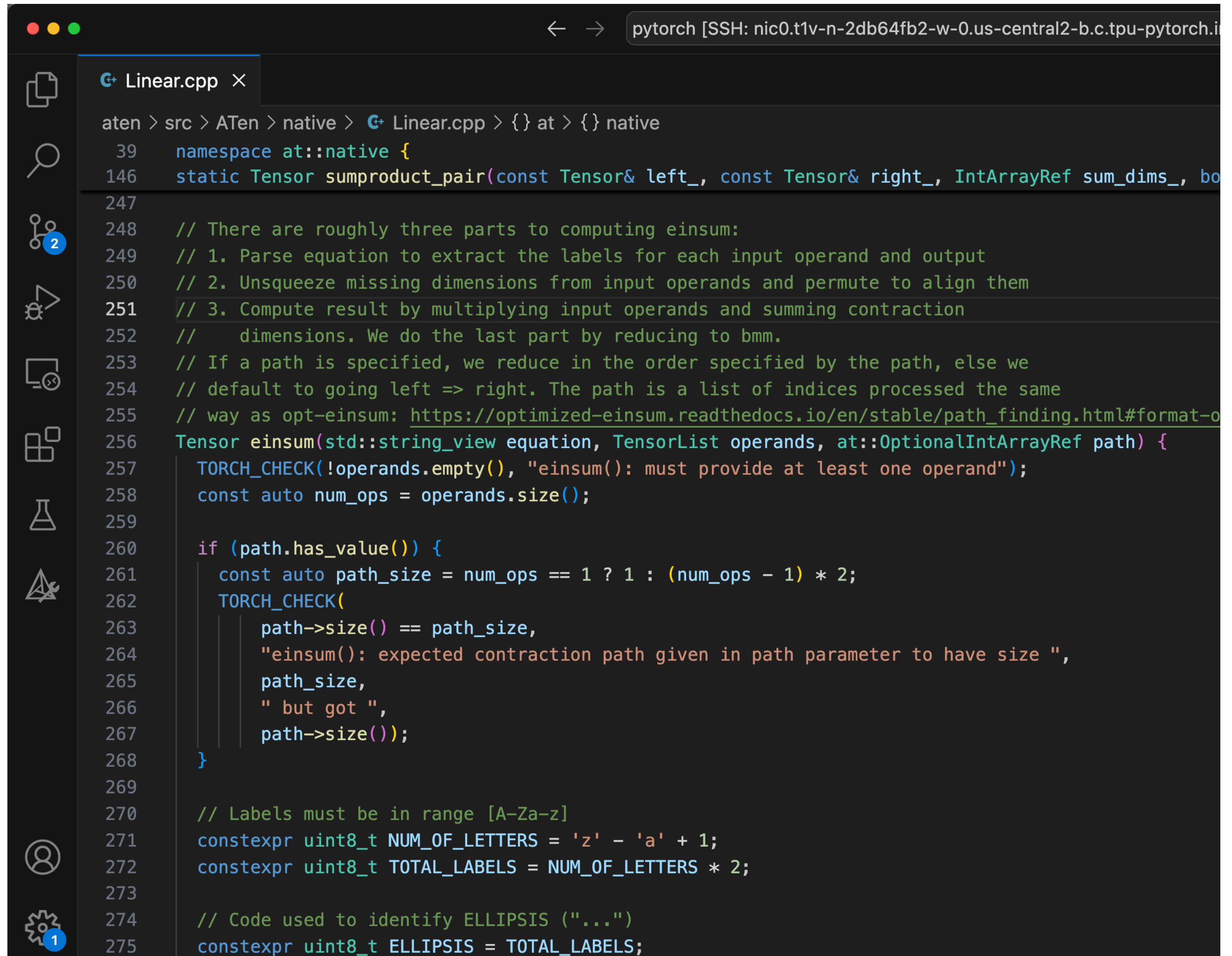
In the output of the `python setup.py develop` command, look for a line that starts with `Source files with custom debug infos` to make sure your file is correctly being built with debugger symbols. For example:

```
--   Public CUDA Deps.    :
--   Private CUDA Deps.   :
--   USE_COREML_DELEGATE     : OFF
--   BUILD_LAZY_TS_BACKEND   : ON
--   USE_ROCM_KERNEL_ASSERT : OFF
-- Source files with custom debug infos: torch/nn/functional.py
-- Configuring done (11.2s)
-- Generating done (1.4s)
-- Build files have been written to: /home/yho_google_com/pytorch/build
[6/34] Building CXX object
caffe2/CMakeFiles/torch_cpu.dir/__/aten/src/ATen/native/mkldnn/...
```

It may also be helpful to ensure that your previous debugger session is shut down.

Using VSCode's Visual Debugger

First, open the file you want to debug.



Second, click to the left of the line number you want to set a breakpoint. You'll see a red dot there, and, in the lower left of the debugger tab.

RUN ... GDB a pythc

VARIABLES

Linear.cpp

aten > src > ATen > native > Linear

```
39   namespace at::native {
146  static Tensor sumproduct_
247
248  // There are roughly thre
249  // 1. Parse equation to e
250  // 2. Unsqueeze missing d
251  // 3. Compute result by m
252  //    dimensions. We do t
253  // If a path is specified
254  // default to going left
255  // way as opt-einsum: htt
256  Tensor einsum(std::string
257    TORCH_CHECK(!operands.e
258    const auto num_ops = op
259
260    if (path.has_value()) {
261      const auto path_size
262      TORCH_CHECK(
263          path->size() == p
264          "einsum(): expect
265          path_size,
266          " but got ",
267          path->size());
268    }
269
270    // Labels must be in ra
271    constexpr uint8_t NUM_O
272    constexpr uint8_t TOTAL
273
274    // Code used to identif
275    constexpr uint8_t ELLIP
```

WATCH

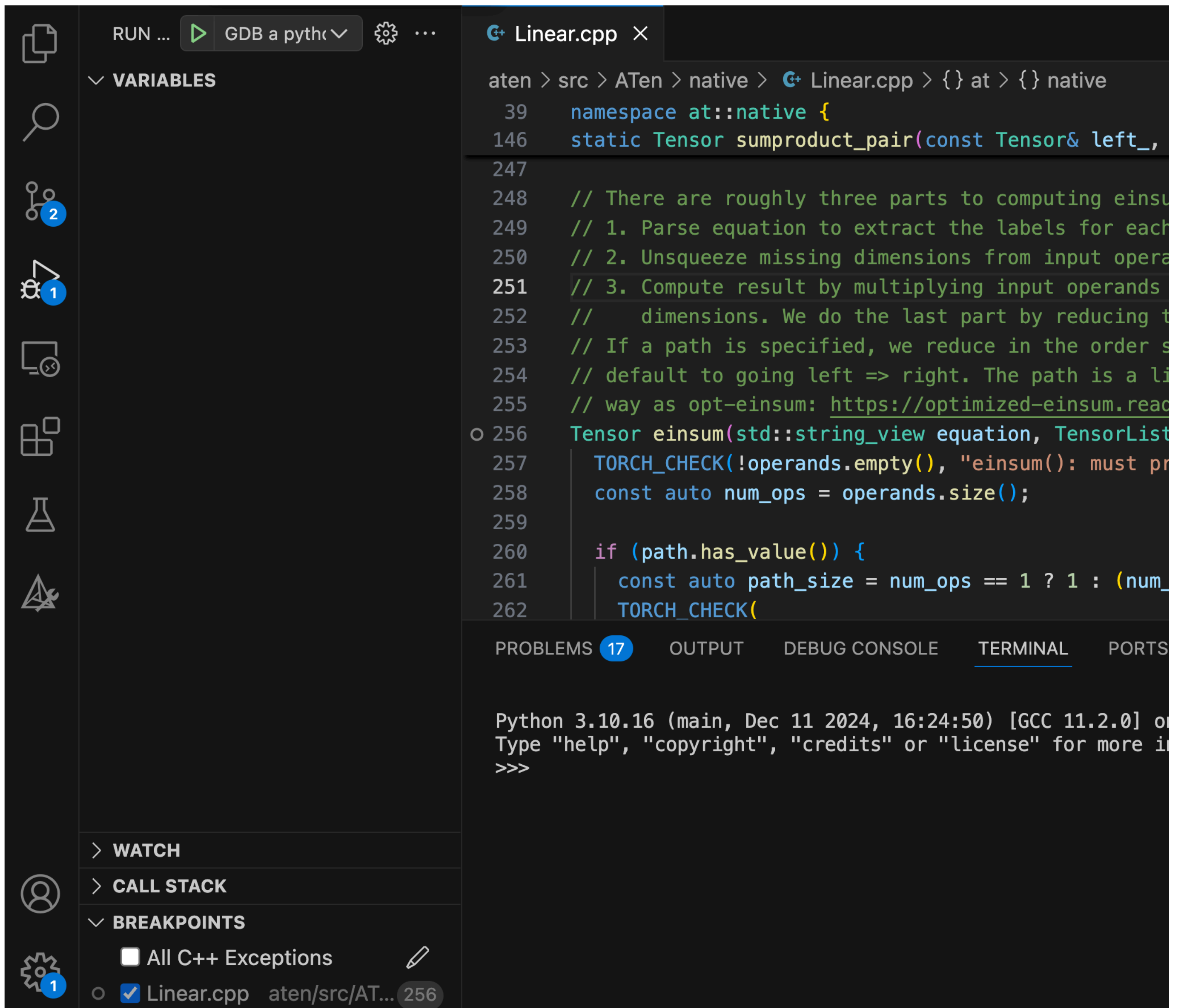
CALL STACK

BREAKPOINTS

All C++ Exceptions

Linear.cpp aten/src/AT... 256

Third, start the debugger session with the green play button. This triggers the rules we set in the launch.json file. Notice that the red button now fades to an empty white circle. That's because you have an active session, but the debugger does not know if it will actually break there. The reason is that you have not imported torch yet, so the torch library you built with debugger symbols is not yet loaded.



In the python interpretor, `import torch`. Now, the breakpoints are active because torch has loaded the underlying C++ libraries.

Run a command that will trigger the breakpoint, namely, `torch.einsum()`. Notice the yellow arrow indicating the current file location, and the variables and call stack information on the left. You are debugging!

RUN ... GDB a pytho
VARIABLES
Locals
> __func__ = [7]
num_ops = <optimized out>
NUM_OF_LETTERS = <optimized ...
TOTAL_LABELS = <optimized ou...
WATCH
CALL STACK
pytho... PAUSED ON BREAKPOINT
libtorch_cpu.so!at::native::ei
libtorch_cpu.so!c10::impl::wra
libtorch_cpu.so!at::_ops::eins
libtorch_python.so!torch::auto
cfunction_call(PyObject * func
_PyObject_MakeTpCall(PyThreadS
_PyObject_VectorcallTstate(PyT
_PyObject_VectorcallTstate(PyT
PyObject_Vectorcall(PyObject *
call_function(PyObject * kwnam
_PyEval_EvalFrameDefault(PyThr
_PyEval_EvalFrame(int throwfla
_PyEval_Vector(PyObject * kwnc
_PyFunction_Vectorcall(PyObjec
BREAKPOINTS
All C++ Exceptions
Linear.cpp aten/src/AT... 256

Linear.cpp

aten > src > ATen > native > Linear.cpp > {} at > {} native >

```
39   namespace at::native {
146  static Tensor sumproduct_pair(const Tensor& left_
247
248  // There are roughly three parts to computing ei
249  // 1. Parse equation to extract the labels for e
250  // 2. Unsqueeze missing dimensions from input op
251  // 3. Compute result by multiplying input operan
252  //    dimensions. We do the last part by reducin
253  // If a path is specified, we reduce in the orde
254  // default to going left => right. The path is a
255  // way as opt-einsum: https://optimized-einsum.r
256  Tensor einsum(std::string_view equation, TensorL
257    TORCH_CHECK(!operands.empty(), "einsum(): must
258    const auto num_ops = operands.size();
259
260    if (path.has_value()) {
261      const auto path_size = num_ops == 1 ? 1 : (n
262      TORCH_CHECK(
```

PROBLEMS 17 OUTPUT DEBUG CONSOLE TERMINAL POR

```
Python 3.10.16 (main, Dec 11 2024, 16:24:50) [GCC 11.2.0]
Type "help", "copyright", "credits" or "license" for more
>>> import torch
>>> torch.einsum("a->", torch.tensor([1.0]))
```

A realistic build command

As you build, you'll collect additional special flags to speed things up, like not building certain libraries or adding diagnostics. Here is one example:

```
USE_CUSTOM_DEBINFO="aten/src/ATen/native/Linear.cpp" USE_CUDA=0
LD_LIBRARY_PATH=/home/USERNAME/miniconda3/envs/torch310/lib CFLAGS="-
DHAS_TORCH_SHOW_DISPATCH_TRACE" python setup.py develop
```

Future Work

This guide has demonstrated how to build debugging symbols for PyTorch. However, comparable flags are not available in the PyTorch/XLA build scripts yet. Future work will include adding those debugger symbol flags so contributors can debug not just PyTorch C++ files, but also PyTorch/XLA C++ files.