

# USING PYBIND11 TO IMPORT YOCTO TO PYTHON

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## Disclaimer

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This project is still not 100% functional, we have been trying everything to fix it, but haven't been able to come up with a solution.

## Installation

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On linux:

```
sudo apt install pybind11-dev
```

Follow the guide of the official repository for the requirements: <https://github.com/pybind/pybind11>

## Include pybind lib

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Clone the repo inside libs folder and add submodule:

```
git submodule add https://github.com/pybind/pybind11
git submodule init
git submodule update
```

<https://github.com/pybind/pybind11/issues/1817>

## Install correctly pybind11

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```
cd pybind11
mkdir build
cd build
cmake ..
make install
```

## How to build yocto

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Now it's possible to build yocto with the python install manager pip:

```
pip install . --no-cache-dir
```

## How to create a module

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Insert the pybindmodule in the principal cmakeLists.txt, and the libs in the cmakeList of yoctoextension (otherwise it will blow up)

## Task

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We were asked to create a python binding to the main Yocto functionality by writing a set of Python scripts interpreting already existing files in Yocto. More specifically we were asked to create 'apps/yscenettrace/yscenettrace.py', 'apps/ysceneproc/ysceneproc.py', 'apps/yimageproc/yimageproc.py', and 'apps/yshapeproc/yshapeproc.py' by binding functions enclosed in the corresponding ".cpp" files to Python, using pybind11.

## What was done

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As instructed we downloaded pybind11 and linked it to the yocto library. We wrote the list of bindings inside "yocto\_extension.cpp" as told, creating a pybind11 module for each header file we bound (yocto\_shapeio, yocto\_image, yocto\_commonio, yocto\_pathtrace, yocto\_sceneio, and filesystem). Inside the modules we added bindings to functions, overloaded functions, constants, classes/structures, and templates that were used by the 3 .py scripts.

## CMake

In order for the pybind11 library to run we had to add lines in 2 CMakeLists.txt files to link everything together:

```
set(PYBIND11_CPP_STANDARD -std=c++1z) # Experimental C++17 support
add_subdirectory(libs/pybind11)
```

The above code was added in the main CMakeLists.txt file in order to point it to the pybind11 library. On top of that, for every module created we had to add:

```
pybind11_add_module(
```

with the name of the module and the file in which it was contained. (as yocto\_extension was used for all the bindings we also had to add a pybind\_add\_module(yocto\_extension) for it). The second CMakeLists.txt we altered was the one in the yocto\_extension directory, where we had to add:

```
target_include_directories(py_module PUBLIC ${CMAKE_SOURCE_DIR}/libs)
target_link_libraries(py_module PRIVATE yocto)
```

replacing `py_module` with the name of each created module in `yocto_extension.cpp` (having one set of "target links" for each module)

## Cmake changes

To allow

```
CMake Error at libs/yocto_extension/CMakeLists.txt:13
(target_link_libraries):
  Attempt to add link library "yocto" to target "py_commonio" which is
  not
  built in this directory.
  This is allowed only when policy CMP0079 is set to NEW.
```

we have setted: `cmake_policy(SET CMP0079 NEW)`

See: [link to issue](#)

## Error with stl containers in pybind11

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To allow the use of `PYBIND11_MAKE_OPAQUE` function we had to move "namespace py = pybind11" outside of every namespace and we moved it upon `yocto::extension` aliases namespace.

## Error with parse\_cli

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Due to a segmentation fault in the `parse_cli` call:

```
jeff2@jeff2-Surface-Book-2 ~/Documents/Fundamentals of computer graphics/CG-FinalProject $ /usr/bin/python3 ./apps/yscenetrace/yscenetrace.py tests/01_surface/surface.json -t path -s 256 -r 720
['./apps/yscenetrace/yscenetrace.py', 'tests/01_surface/surface.json', '-t', 'path', '-s', '256', '-r', '720']
<capsule object NULL at 0x7fc9a3823900>
cli argument parse
ioscene created
Segmentation fault (core dumped) 00:00.000 load scene
```

we had to create a workaround by creating a simplified `parce_cli` in python. Main problem is in \*

```
(std::string*)option.value = value; /*(std::string*) create the problem inside
inline bool parse_cli(cli_state& cli, int argc, const char** argv, std::string& error)"; it looks like it cant convert the object into an std::string pointer.
```

We tried with differen methods, like creating a lambda function that wraps the parse cli function and call directly from the cpp file (see [strackoverflow](#)), but even with this method it doesn't seems to work.

# Error with yocto\_sceneio

To avoid the error below, while creating a new module for yocto\_sceneio (and others):

```
[build] [6/10 20% :: 17.749] Building CXX object CMakeFiles/py_sceneio.dir/libs/yocto_extension/yocto_extension.cpp.o
[build] [7/10 30% :: 17.793] Building CXX object CMakeFiles/py_pathtrace.dir/libs/yocto_extension/yocto_extension.cpp.o
[build] [8/10 40% :: 17.984] Linking CXX static library ../../bin/debug/libyocto_extension.a
[build] [8/10 50% :: 18.218] Building CXX object CMakeFiles/py_commonio.dir/libs/yocto_extension/yocto_extension.cpp.o
[build] [9/10 60% :: 18.452] Building CXX object CMakeFiles/py_trace.dir/libs/yocto_extension/yocto_extension.cpp.o
[build] [10/10 70% :: 18.866] Linking CXX shared module py_pathtrace.cpython-36m-x86_64-linux-gnu.so
[build] FAILED: py_pathtrace.cpython-36m-x86_64-linux-gnu.so
[build] : 66 /usr/bin/clang++-9 -fPIC -g -shared -o py_pathtrace.cpython-36m-x86_64-linux-gnu.so CMakeFiles/py_pathtrace.dir/libs/yocto_extension/yocto_extension.cpp.o ../../bin/debug/libyocto.a ../../bin/debug/libyocto.a
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(yocto_image.cpp.o): relocation R_X86_64_32 against `.rodata.str1.1' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(stb_image.cpp.o): relocation R_X86_64_32S against `.bss' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(cgltf.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(tinyexr.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: link finale non riuscito: Nonrepresentable section on output
[build] clang: error: linker command failed with exit code 1 (use -v to see invocation)
[build] [10/10 80% :: 18.893] Linking CXX shared module py_sceneio.cpython-36m-x86_64-linux-gnu.so
[build] FAILED: py_sceneio.cpython-36m-x86_64-linux-gnu.so
[build] : 66 /usr/bin/clang++-9 -fPIC -g -shared -o py_sceneio.cpython-36m-x86_64-linux-gnu.so CMakeFiles/py_sceneio.dir/libs/yocto_extension/yocto_extension.cpp.o ../../bin/debug/libyocto.a ../../bin/debug/libyocto.a
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(yocto_image.cpp.o): relocation R_X86_64_32 against `.rodata.str1.1' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(stb_image.cpp.o): relocation R_X86_64_32S against `.bss' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(cgltf.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(tinyexr.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: link finale non riuscito: Nonrepresentable section on output
[build] clang: error: linker command failed with exit code 1 (use -v to see invocation)
[build] [10/10 90% :: 19.204] Linking CXX shared module py_commonio.cpython-36m-x86_64-linux-gnu.so
[build] FAILED: py_commonio.cpython-36m-x86_64-linux-gnu.so
[build] : 66 /usr/bin/clang++-9 -fPIC -g -shared -o py_commonio.cpython-36m-x86_64-linux-gnu.so CMakeFiles/py_commonio.dir/libs/yocto_extension/yocto_extension.cpp.o ../../bin/debug/libyocto.a ../../bin/debug/libyocto.a
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(yocto_image.cpp.o): relocation R_X86_64_32 against `.rodata.str1.1' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(stb_image.cpp.o): relocation R_X86_64_32S against `.bss' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(cgltf.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(tinyexr.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: link finale non riuscito: Nonrepresentable section on output
[build] clang: error: linker command failed with exit code 1 (use -v to see invocation)
[build] [10/10 100% :: 19.536] Linking CXX shared module py_trace.cpython-36m-x86_64-linux-gnu.so
[build] FAILED: py_trace.cpython-36m-x86_64-linux-gnu.so
[build] : 66 /usr/bin/clang++-9 -fPIC -g -shared -o py_trace.cpython-36m-x86_64-linux-gnu.so CMakeFiles/py_trace.dir/libs/yocto_extension/yocto_extension.cpp.o CMakeFiles/py_trace.dir/libs/yocto/yocto_trace.cpp.o ../../bin/de
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(yocto_image.cpp.o): relocation R_X86_64_32 against `.rodata.str1.1' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(stb_image.cpp.o): relocation R_X86_64_32S against `.bss' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(cgltf.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: ../../bin/debug/libyocto.a(tinyexr.cpp.o): relocation R_X86_64_32S against `.rodata' can not be used when making a shared object; recompile with -fPIC
[build] /usr/bin/ld: link finale non riuscito: Nonrepresentable section on output
[build] clang: error: linker command failed with exit code 1 (use -v to see invocation)
[build] ninja: build stopped: subcommand failed.
[build] Compilazione terminata con codice di uscita 1
```

we had to include all the all the yocto cpp file:

```
#include <yocto/yocto_commonio.h>
#include <yocto/yocto_image.h>
#include <yocto/yocto_image.cpp>
#include <yocto/ext/stb_image.h>
#include <yocto/ext/stb_image.cpp>

#include <yocto/yocto_sceneio.cpp>
#include <yocto/yocto_trace.h>
#include <yocto/ext/cgltf.cpp>
#include <yocto/ext/tinyexr.cpp>

#include <yocto/yocto_shape.h>
#include <yocto/yocto_shape.cpp>
```

## yscenetrace problem

The binding of yscenetrace.cpp file caused the majority of problems:

1. parce cli had to be redefined as we had problems with
2. in init\_subdivs a floating point exception was created inside eval\_textures in pathtrace.cpp:

```
auto ii = (i + 1) % size.x, jj = (j + 1) % size.y; //size is equal to (0,0)
```

this happens because in the init\_scene function, in the loop over ioscene.objects, set\_subdiv\_displacement function set a displacement\_tex = nullptr, infact texture\_map[iobject.material.displacement\_tex] is a Null/None, even if the texture\_map is correctly created:

```
ptr.set_subdiv_displacement(subdiv_map[iobject.subdiv],
    iobject.material.displacement,
    texture_map[iobject.material.displacement_tex])
```

we managed to dodge the problem, at least for testing purpose, creating a `iotexture_tmp` index inside the loop over `ioscene.textures`:

```
for iotexture in ioscene.textures:
    if progress_cb:
        progress.x += 1
        progress_cb("convert texture", progress.x, progress.y)
    texture = ptr.add_texture(scene)
    # if ptr.texture_empty(texture, 'colorf'):
    if texture.colorf:
        ptr.set_texture(texture, iotexture.colorf)
        size_colorf = img.image_vec3f.size(iotexture.colorf)
        if size_colorf.x:
            iotexture_tmp = iotexture

    ...

    ptr.set_subdiv_displacement(subdiv_map[iobject.subdiv],
        iobject.material.displacement,
        texture_map[iotexture_tmp])
```

We then encountered another problem, however, in the `pathtrace::trace_samples` function, created inside the `eval_camera`, specifically at this line:

```
auto p = dc * camera->focus / abs(dc.z);
```

Where the division by `abs(dc.z)` ended up giving a value of infinity. We tested it by printing out the value of `dc.z`:

```
cli::print_info("Inside eval_camera, dc.z: " + std::to_string(dc.z));
```

```
Inside eval_camera, dc.z: 0.983158
Inside eval_camera, dc.z: 0.983204
Inside eval_camera, dc.z: 0.983065
Inside eval_camera, dc.z: 0.983240
Inside eval_camera, dc.z: 0.983212
Inside eval_camera, dc.z: 0.983251
Inside eval_camera, dc.z: 0.983235
Inside eval_camera, dc.z: 0.983272
Inside eval_camera, dc.z: 0.983285
```

```
Inside eval_camera, dc.z: 0.983204
Inside eval_camera, dc.z: 0.983212
Inside eval_camera, dc.z: 0.983170
Inside eval_camera, dc.z: 0.983138
```

The above output repeated for several thousands of lines and then cut out, meaning we were not able to decipher where the value goes to 0. As such This problem remains unresolved.

## yshapeproc problem

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In yshapeproc the problem is created inside the `make_*` functions, the vectors passed to them (such as quads, positions, etc.) are not being changed. To avoid this problem we have tried different possible solutions, such as exposing stl containers as native Python object, as stated in pybind documentation ([expose stl container](#)):

```
PYBIND11_MAKE_OPAQUE(std::vector<int>);
PYBIND11_MAKE_OPAQUE(std::vector<float>);
PYBIND11_MAKE_OPAQUE(std::vector<yocto::math::vec2f>);
PYBIND11_MAKE_OPAQUE(std::vector<yocto::math::vec3f>);
PYBIND11_MAKE_OPAQUE(std::vector<yocto::math::vec2i>);
PYBIND11_MAKE_OPAQUE(std::vector<yocto::math::vec3i>);
PYBIND11_MAKE_OPAQUE(std::vector<yocto::math::vec4i>);
...
py::bind_vector<std::vector<int>>(m, "VectorInt", py::module_local(false));
py::bind_vector<std::vector<float>>(m, "VectorFloat",
py::module_local(false));
py::bind_vector<std::vector<vec2f>>(m, "VectorVec2f",
py::module_local(false));
py::bind_vector<std::vector<vec3f>>(m, "VectorVec3f",
py::module_local(false));
py::bind_vector<std::vector<vec2i>>(m, "VectorVec2i",
py::module_local(false));
py::bind_vector<std::vector<vec3i>>(m, "VectorVec3i",
py::module_local(false));
py::bind_vector<std::vector<vec4i>>(m, "VectorVec4i",
py::module_local(false));
```

but even with this method we ended up with the same empty vectors problem.