

A3作业

1.安装gcc/g++

安装g++:

```
(base) zhangkeer@zhangkeer-virtual-machine:~$ which gcc g++
/usr/bin/gcc
(base) zhangkeer@zhangkeer-virtual-machine:~$ g++ --version

Command 'g++' not found, but can be installed with:

sudo apt install g++

(base) zhangkeer@zhangkeer-virtual-machine:~$ sudo apt install g++
[sudo] password for zhangkeer:
Reading package lists... Done
Building dependency tree
Reading state information... Done
The following additional packages will be installed:
  g++-9
Suggested packages:
  g++-multilib g++-9-multilib gcc-9-doc
The following NEW packages will be installed:
  g++ g++-9
0 upgraded, 2 newly installed, 0 to remove and 4 not upgraded.
Need to get 8,407 kB of archives.
After this operation, 28.7 MB of additional disk space will be used.
Do you want to continue? [Y/n] Y
Get:1 http://mirrors.aliyun.com/ubuntu focal-security/main amd64 g++-9 amd64 9.3.0-17ubuntu1~20.04 [8,405 kB]
Get:2 http://mirrors.aliyun.com/ubuntu focal/main amd64 g++ amd64 4:9.3.0-1ubuntu2 [1,604 B]
Fetched 8,407 kB in 3s (3,311 kB/s)
Selecting previously unselected package g++-9.
(Reading database ... 197715 files and directories currently installed.)
Preparing to unpack .../g++-9_9.3.0-17ubuntu1~20.04_amd64.deb ...
Unpacking g++-9 (9.3.0-17ubuntu1~20.04) ...
Selecting previously unselected package g++.
Preparing to unpack .../g++_4%3a9.3.0-1ubuntu2_amd64.deb ...
Unpacking g++ (4:9.3.0-1ubuntu2) ...
Setting up g++-9 (9.3.0-17ubuntu1~20.04) ...
Setting up g++ (4:9.3.0-1ubuntu2) ...
update-alternatives: using /usr/bin/g++ to provide /usr/bin/c++ (c++) in auto mode
Processing triggers for man-db (2.9.1-1) ...
(base) zhangkeer@zhangkeer-virtual-machine:~$
```

安装9.3.0版本的gcc和g++后:

```
(base) zhangkeer@zhangkeer-virtual-machine:~$ which gcc g++
/usr/bin/gcc
/usr/bin/g++
(base) zhangkeer@zhangkeer-virtual-machine:~$ gcc --version
gcc (Ubuntu 9.3.0-17ubuntu1~20.04) 9.3.0
Copyright (C) 2019 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

(base) zhangkeer@zhangkeer-virtual-machine:~$ g++ --version
g++ (Ubuntu 9.3.0-17ubuntu1~20.04) 9.3.0
Copyright (C) 2019 Free Software Foundation, Inc.
This is free software; see the source for copying conditions. There is NO
warranty; not even for MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

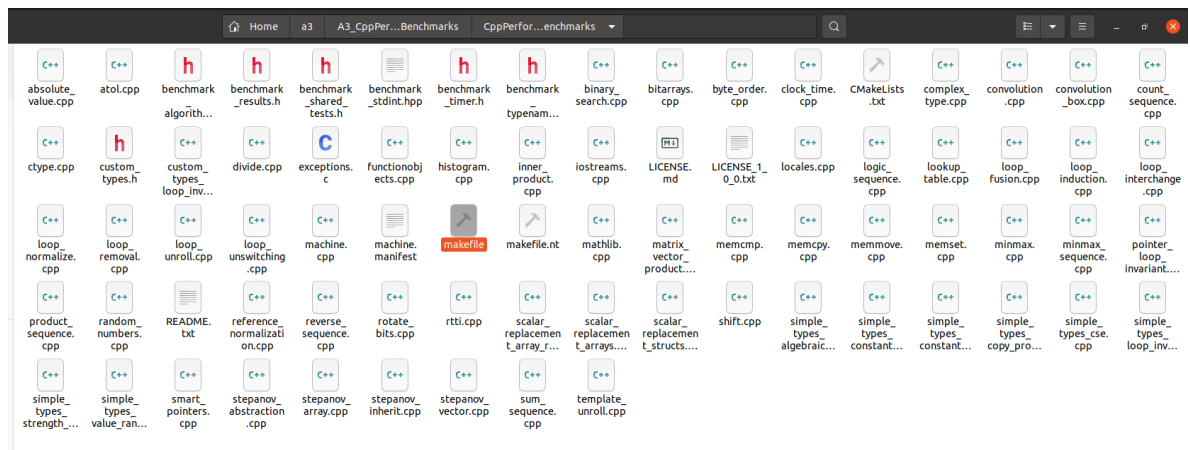
(base) zhangkeer@zhangkeer-virtual-machine:~$
```

2.安装Clang/LLVM

```
(base) zhangkeer@zhangkeer-virtual-machine:~$ which clang clang++
/usr/bin/clang
/usr/bin/clang++
(base) zhangkeer@zhangkeer-virtual-machine:~$
```

```
(base) zhangkeer@zhangkeer-virtual-machine:~$ clang --version
clang version 10.0.0-4ubuntu1
Target: x86_64-pc-linux-gnu
Thread model: posix
InstalledDir: /usr/bin
(base) zhangkeer@zhangkeer-virtual-machine:~$ clang++ --version
clang version 10.0.0-4ubuntu1
Target: x86_64-pc-linux-gnu
Thread model: posix
InstalledDir: /usr/bin
(base) zhangkeer@zhangkeer-virtual-machine:~$
```

3.安装性能测试集



4.编译器及优化选项的组合测试

修改makefile:

```

}
#
} # our target programs
} #
}
) BINARIES = divide \
L
}
}
}

```

```

report: $(BINARIES)
    echo "##STARTING Version 1.0" > $(REPORT_FILE)
    date >> $(REPORT_FILE)
    echo "##Compiler: $(CC) $(CXX)" >> $(REPORT_FILE)
    echo "##CFlags: $(CFLAGS)" >> $(REPORT_FILE)
    echo "##CPPFlags: $(CPPFLAGS)" >> $(REPORT_FILE)
    echo "System Information collected by program: " >> $(REPORT_FILE)
    ./divide >> $(REPORT_FILE)
    date >> $(REPORT_FILE)
    echo "##END Version 1.0" >> $(REPORT_FILE)

```

使用divide.cpp进行测试，主要和除法、模相关的计算有关

该测试涉及的数据类型有int16_t, uint16_t, int32_t, uint32_t, int64_t, uint64_t, float, double共8种

clang O0

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=clang CXX=clang++ OPTLEVEL=-O0
clang++ -std=c++14 -I. -O0 divide.cpp -o divide
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: clang clang++" >> report.txt
echo "##CFlags: -I. -O0 " >> report.txt
echo "##CPPFlags: -std=c++14 -I. -O0 " >> report.txt
echo "System Information collected by program: " >> report.txt
./divide >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ mv report.txt report.txt.divide.clang-O0
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 58744 10月 9 14:17 divide
```

clang O1

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=clang CXX=clang++ OPTLEVEL=-O1
clang++ -std=c++14 -I. -O1 divide.cpp -o divide
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: clang clang++" >> report.txt
echo "##CFlags: -I. -O1 " >> report.txt
echo "##CPPFlags: -std=c++14 -I. -O1 " >> report.txt
echo "System Information collected by program: " >> report.txt
./divide >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ mv report.txt report.txt.divide.clang-O1
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 54704 10月 9 14:23 divide
```

clang O2

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=clang CXX=clang++ OPTLEVEL=-O2
clang++ -std=c++14 -I. -O2 divide.cpp -o divide
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: clang clang++" >> report.txt
echo "##CFlags: -I. -O2 " >> report.txt
echo "##CPPFlags: -std=c++14 -I. -O2 " >> report.txt
echo "System Information collected by program: " >> report.txt
./divide >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ mv report.txt report.txt.divide.clang-O2
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 58744 10月 9 14:29 divide
```

gcc O0

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=gcc CXX=g++ OPTLEVEL=-O0
g++ -std=c++14 -I. -O0 divide.cpp -o divide
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: gcc g++" >> report.txt
echo "##CFlags: -I. -O0 " >> report.txt
echo "##CPPFlags: -std=c++14 -I. -O0 " >> report.txt
echo "System Information collected by program: " >> report.txt
./divide >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 59184 10月 9 14:31 divide
```

gcc O1

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=gcc CXX=g++ OPTLEVEL=-O1
g++ -std=c++14 -I. -O1 divide.cpp -o divide
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: gcc g++" >> report.txt
echo "##CFlags: -I. -O1 " >> report.txt
echo "##CPPFlags: -std=c++14 -I. -O1 " >> report.txt
echo "System Information collected by program: " >> report.txt
./divide >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ ls -l
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 31088 10月 9 14:34 divide
```

gcc O2

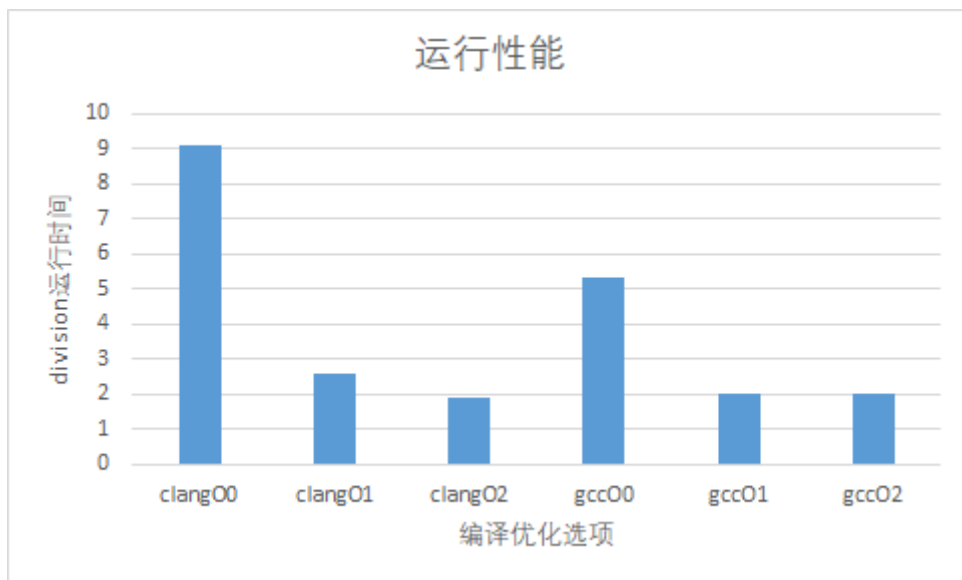
```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=gcc CXX=g++ OPTLEVEL=-O2
g++ -std=c++14 -I. -O2 divide.cpp -o divide
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: gcc g++" >> report.txt
echo "##CFlags: -I. -O2 " >> report.txt
echo "##CPPFlags: -std=c++14 -I. -O2 " >> report.txt
echo "System Information collected by program: " >> report.txt
./divide >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 41544 10月 9 14:36 divide
```

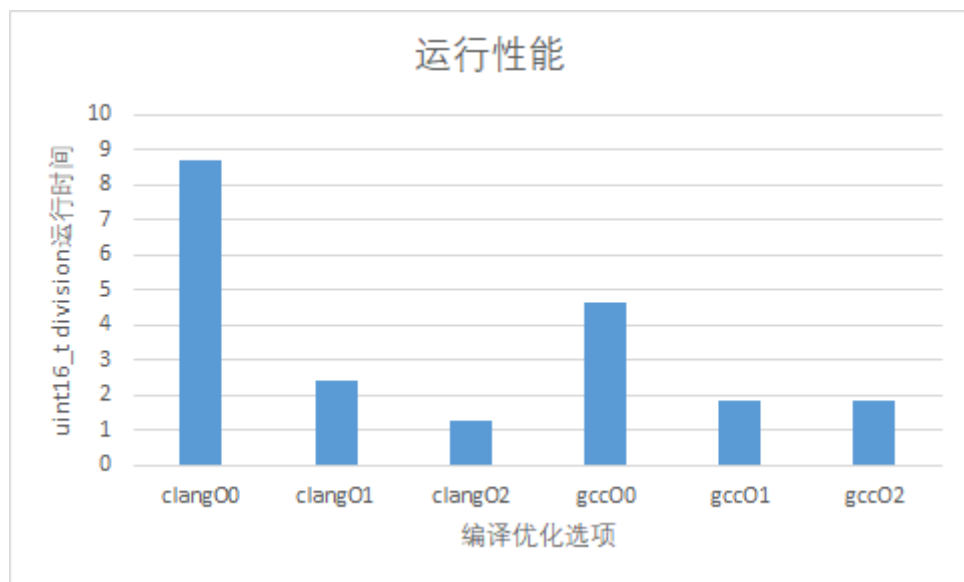
5. 测试数据的分析

对8种数据类型，整体上gcc/g++、clang/LLVM不同种类编译器的对性能的影响没有明显区别：有的数据类型Clang运行时间优于gcc，反之亦存在。

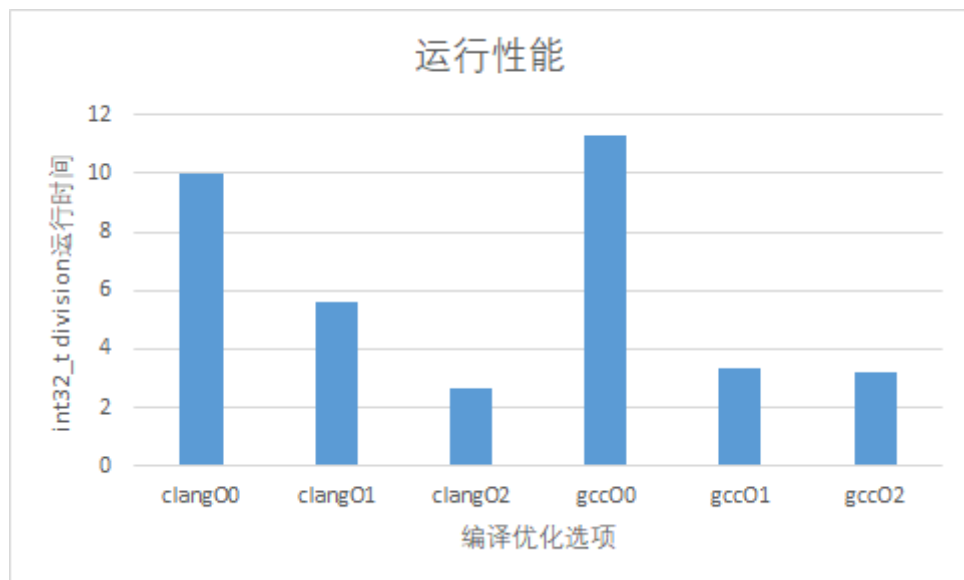
Total absolute time for int16_t division:



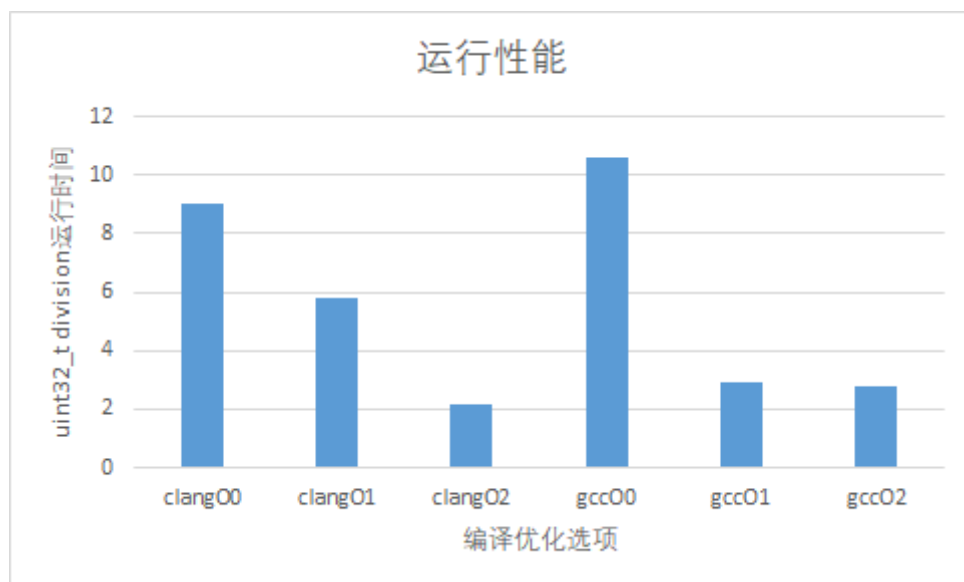
Total absolute time for uint16_t division:



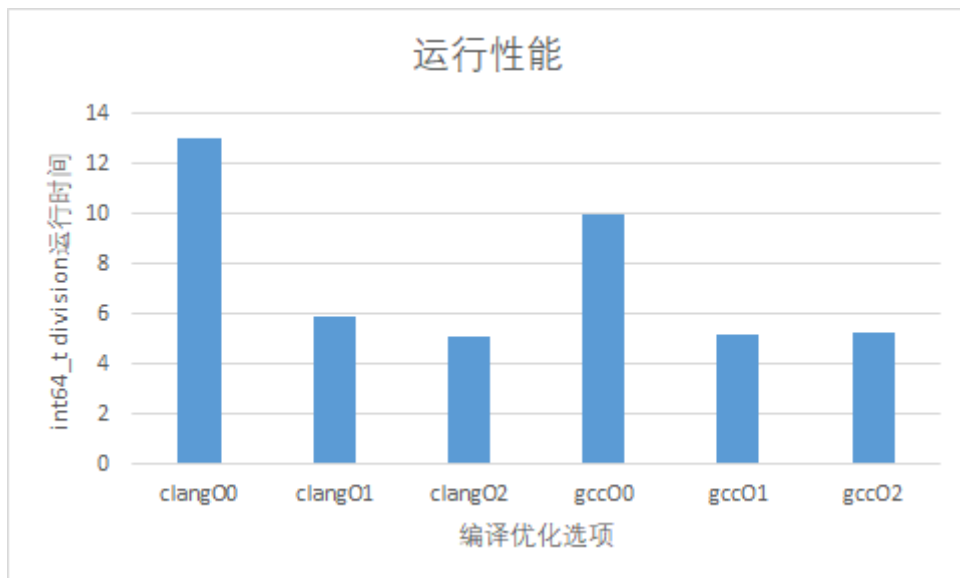
Total absolute time for `int32_t` division:



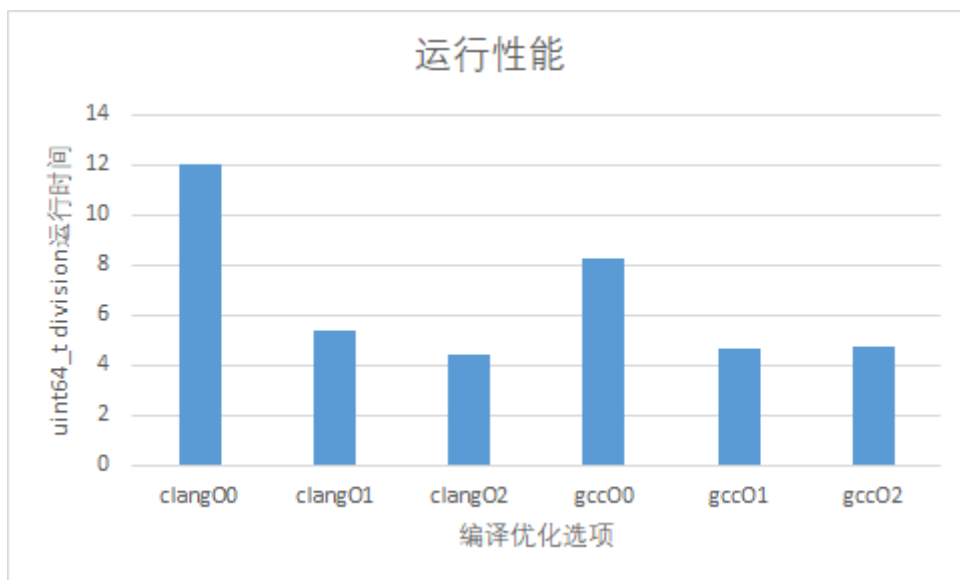
Total absolute time for `uint32_t` division:



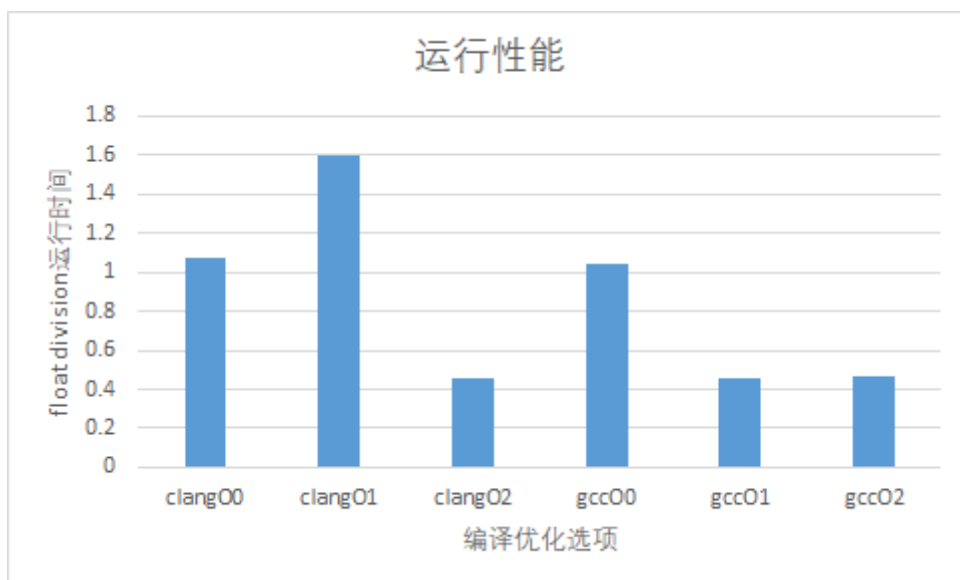
Total absolute time for int64_t division:



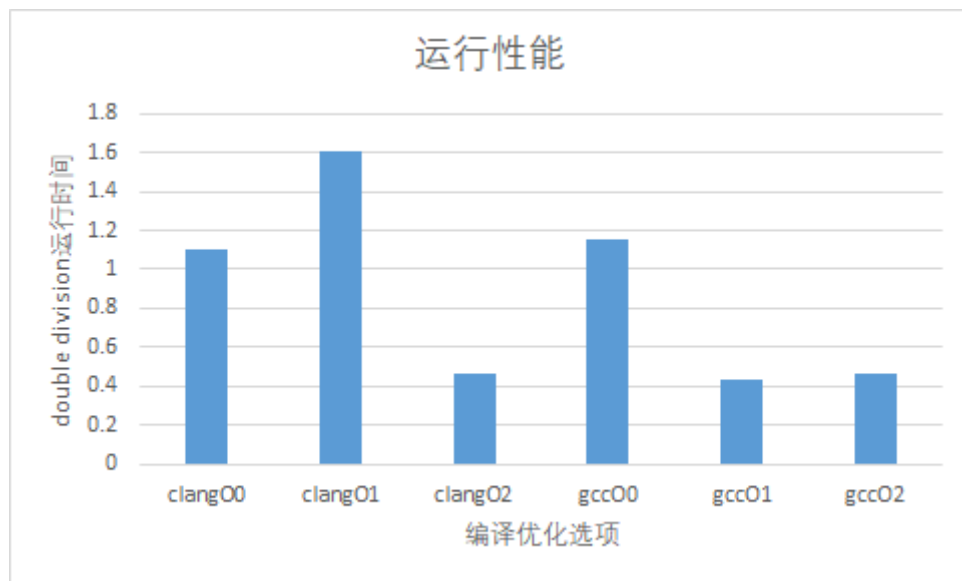
Total absolute time for uint64_t division:



Total absolute time for float division:



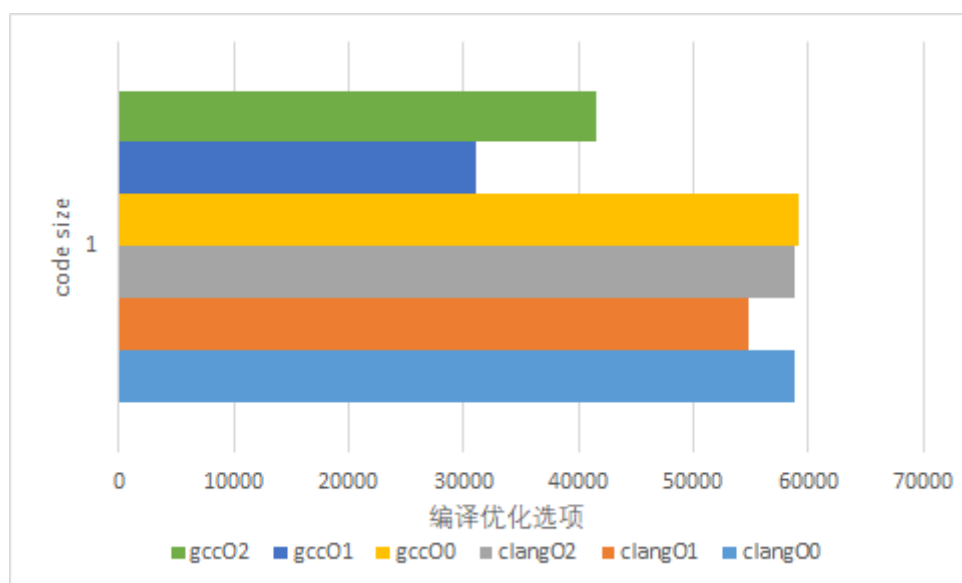
Total absolute time for double division:



大部分情况下，-O1和-O2的运行时间会比-O0更短，因为-O0是编译器不做优化处理，而-O1和-O2执行了更多优化选项，提高了程序的性能。

对于int16_t, uint16_t, int32_t, uint32_t, int64_t, uint64_t数据类型，两种编译器而言，-O0性能最差，-O1可以大幅提升程序性能，-O2可以在此基础上提升小部分；而对于float和double，可以看到Clang/LLVM -O1的优化选项反而会降低程序的性能，我猜测这与Clang/LLVM本身对浮点数的处理有关，但-O2优化效果较好；同时gcc/g++仍符合-O1、-O2优化效果很好的规律。

关于不同优化选项下的code size，gcc/g++ -O0是59184，gcc/g++ -O1是31088，gcc/g++ -O2是41544，可见优化后可执行文件的大小也会发生变化，但并不是优化做得越多code size越小，有时为了性能提升优化后的代码量反而增大。Clang/LLVM -O0是58744，Clang/LLVM -O1是54704，Clang/LLVM -O2是58744，这里-O0和-O2的code size一样应该是巧合，我反复编译了几次应该没有搞错。



6.错误记录

从练习的pdf直接复制粘贴到ubuntu的命令行会丢失短杠，导致并没有改变优化选项。因此之前实验的code size全部相同，性能也没有明显规律，检查后才发现有报错。

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=gcc CXX=g++ OPTLEVEL= 00
g++ -std=c++14 -I. loop_interchange.cpp -o loop_interchange
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: gcc g++" >> report.txt
echo "##CFlags: -I. " >> report.txt
echo "##CPPFlags: -std=c++14 -I. " >> report.txt
echo "System Information collected by program: " >> report.txt
./loop_interchange >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
make: *** No rule to make target '00'. Stop.
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 114456 10月 2 16:40 loop_interchange
```

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=gcc CXX=g++ OPTLEVEL= 01
g++ -std=c++14 -I. loop_interchange.cpp -o loop_interchange
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: gcc g++" >> report.txt
echo "##CFlags: -I. " >> report.txt
echo "##CPPFlags: -std=c++14 -I. " >> report.txt
echo "System Information collected by program: " >> report.txt
./loop_interchange >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
make: *** No rule to make target '01'. Stop.
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 114456 10月 2 17:08 loop_interchange
```

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=gcc CXX=g++ OPTLEVEL= 02
g++ -std=c++14 -I. loop_interchange.cpp -o loop_interchange
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: gcc g++" >> report.txt
echo "##CFlags: -I. " >> report.txt
echo "##CPPFlags: -std=c++14 -I. " >> report.txt
echo "System Information collected by program: " >> report.txt
./loop_interchange >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
make: *** No rule to make target '02'. Stop.
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 114456 10月 2 19:49 loop_interchange
```

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=clang CXX=clang++ OPTLEVEL= 00
clang++ -std=c++14 -I. loop_interchange.cpp -o loop_interchange
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: clang clang++" >> report.txt
echo "##CFlags: -I. " >> report.txt
echo "##CPPFlags: -std=c++14 -I. " >> report.txt
echo "System Information collected by program: " >> report.txt
./loop_interchange >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
make: *** No rule to make target '00'. Stop.
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 117936 10月 2 16:00 loop_interchange
```

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make clean
rm -f *.o loop_interchange report.txt
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=clang CXX=clang++ OPTLEVEL= 01
clang++ -std=c++14 -I. loop_interchange.cpp -o loop_interchange
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: clang clang++" >> report.txt
echo "##CFlags: -I. " >> report.txt
echo "##CPPFlags: -std=c++14 -I. " >> report.txt
echo "System Information collected by program: " >> report.txt
./loop_interchange >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
make: *** No rule to make target '01'. Stop.
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ mv report.txt report.txt.clang-01
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 117936 10月 2 15:25 loop_interchange
```

```
(base) zhangkeer@zhangkeer-virtual-machine:~/a3/A3_CppPerformanceBenchmarks/CppPerformanceBenchmarks$ make report CC=clang CXX=clang++ OPTLEVEL= 02
clang++ -std=c++14 -I. loop_interchange.cpp -o loop_interchange
echo "##STARTING Version 1.0" > report.txt
date >> report.txt
echo "##Compiler: clang clang++" >> report.txt
echo "##CFlags: -I. " >> report.txt
echo "##CPPFlags: -std=c++14 -I. " >> report.txt
echo "System Information collected by program: " >> report.txt
./loop_interchange >> report.txt
date >> report.txt
echo "##END Version 1.0" >> report.txt
make: *** No rule to make target '02'. Stop.
```

```
-rwxrwxr-x 1 zhangkeer zhangkeer 117936 10月 2 16:18 loop_interchange
```