Задание 2
Отчёт
по CUDA ADI3d

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1. Постановка задачи

1. Программа должна автоматически определять доступный объём памяти на GPU и выбирать максимально возможный размер сетки (L), который поместится в эту память.

2. Нужно реализовать возможность запуска на CPU и GPU, а также режим сравнения, чтобы проверить, что результаты расчётов одинаковы.

3. Редукцию (вычисление максимального значения ошибки eps) необходимо распараллелить. В программе уже используется атомарная операция на GPU, но она может быть оптимизирована.

4. Создайте Git-репозиторий с вашим кодом. В нём должен быть:

•Makefile, который позволит собрать и запустить программу на любом сервере с GPU.

•Возможность выбирать, на каком устройстве (CPU или GPU) будет выполняться программа.

•Режим проверки совпадения результатов между CPU и GPU.

5. Проверьте производительность программы:

•Сравните время выполнения программы на GPU и CPU.

•Постройте таблицу или график, показывающий ускорение программы на GPU по сравнению с последовательной версией на CPU (с максимальными опциями оптимизации).

2. Формат командной строки

nvcc adi3d_cuda.cu -o cuda2

3. Спецификация системы

- Operating system : Linux 6.8.0-45-generic
- Vendor string and code : GenuineIntel (1, 0x1)
- Model string and code : Intel(R) Core(TM) i7-10750H CPU @ 2.60GHz (165, 0xa5)
- CPU revision : 2.000000
- CPUID : Family/Model/Stepping 6/165/2, 0x06/0xa5/0x02
- CPU Max MHz : 5000
- CPU Min MHz : 800
- Total cores : 12

- SMT threads per core : 2
- Cores per socket : 6
- Sockets : 1
- Cores per NUMA region : 12
- NUMA regions : 1
- Running in a VM : no
- Number Hardware Counters : 10
- Max Multiplex Counters : 384

4. Описание алгоритмов

Для этой программы был написан файл Makefile.

Введите следующую команду в терминале:

nvcc adi3d_cuda.cu -o cuda

После этого мы войдем:

make run_cpu

Программа будет запущена на CPU, и результаты показаны справа в таблице ниже.

make run_gpu

Программа будет запущена на GPU, и результаты показаны слева в таблице ниже.

5.Заключение

collapsor@collapsor-G5-5500:~/Desktop/CUDA$ nvcc adi3d_cuda.cu -o cuda

collapsor@collapsor-G5-5500:~/Desktop/CUDA$ ./cuda

Free memory: 1106247680 bytes

Total memory: 6020661248 bytes

Dynamic grid size set to: 332 x 332 x 332

Running on GPU...	*Running on CPU...*
GPU IT = 1 EPS = 1.4939577E+01	*CPU IT = 1 EPS = 1.4939577E+01*
GPU IT = 2 EPS = 7.4546828E+00	*CPU IT = 2 EPS = 7.4546828E+00*
GPU IT = 3 EPS = 3.7197885E+00	*CPU IT = 3 EPS = 3.7197885E+00*
GPU IT = 4 EPS = 2.7841767E+00	*CPU IT = 4 EPS = 2.7841767E+00*
GPU IT = 5 EPS = 2.0838841E+00	*CPU IT = 5 EPS = 2.0838841E+00*
GPU IT = 6 EPS = 1.6174943E+00	*CPU IT = 6 EPS = 1.6174943E+00*
GPU IT = 7 EPS = 1.3835914E+00	*CPU IT = 7 EPS = 1.3835914E+00*
GPU IT = 8 EPS = 1.1865898E+00	*CPU IT = 8 EPS = 1.1865898E+00*
GPU IT = 9 EPS = 1.0262684E+00	*CPU IT = 9 EPS = 1.0262684E+00*

Running on GPU...	Running on CPU...
GPU IT = 10 EPS = 8.9621378E-01	CPU IT = 10 EPS = 8.9621378E-01
GPU IT = 11 EPS = 8.1386743E-01	CPU IT = 11 EPS = 8.1386743E-01
GPU IT = 12 EPS = 7.4003912E-01	CPU IT = 12 EPS = 7.4003912E-01
GPU IT = 13 EPS = 6.7499491E-01	CPU IT = 13 EPS = 6.7499491E-01
GPU IT = 14 EPS = 6.1804058E-01	CPU IT = 14 EPS = 6.1804058E-01
GPU IT = 15 EPS = 5.6770197E-01	CPU IT = 15 EPS = 5.6770197E-01
GPU IT = 16 EPS = 5.3173036E-01	CPU IT = 16 EPS = 5.3173036E-01
GPU IT = 17 EPS = 4.9832553E-01	CPU IT = 17 EPS = 4.9832553E-01
GPU IT = 18 EPS = 4.6790273E-01	CPU IT = 18 EPS = 4.6790273E-01
GPU IT = 19 EPS = 4.3984770E-01	CPU IT = 19 EPS = 4.3984770E-01
GPU IT = 20 EPS = 4.1435740E-01	CPU IT = 20 EPS = 4.1435740E-01
GPU IT = 21 EPS = 3.9085728E-01	CPU IT = 21 EPS = 3.9085728E-01
GPU IT = 22 EPS = 3.7277002E-01	CPU IT = 22 EPS = 3.7277002E-01
GPU IT = 23 EPS = 3.5568000E-01	CPU IT = 23 EPS = 3.5568000E-01
GPU IT = 24 EPS = 3.3966110E-01	CPU IT = 24 EPS = 3.3966110E-01
GPU IT = 25 EPS = 3.2465039E-01	CPU IT = 25 EPS = 3.2465039E-01
GPU IT = 26 EPS = 3.1051412E-01	CPU IT = 26 EPS = 3.1051412E-01
GPU IT = 27 EPS = 2.9735018E-01	CPU IT = 27 EPS = 2.9735018E-01
GPU IT = 28 EPS = 2.8494276E-01	CPU IT = 28 EPS = 2.8494276E-01
GPU IT = 29 EPS = 2.7487311E-01	CPU IT = 29 EPS = 2.7487311E-01
GPU IT = 30 EPS = 2.6529327E-01	CPU IT = 30 EPS = 2.6529327E-01
GPU IT = 31 EPS = 2.5612042E-01	CPU IT = 31 EPS = 2.5612042E-01
GPU IT = 32 EPS = 2.4742678E-01	CPU IT = 32 EPS = 2.4742678E-01
GPU IT = 33 EPS = 2.3914235E-01	CPU IT = 33 EPS = 2.3914235E-01
GPU IT = 34 EPS = 2.3122085E-01	CPU IT = 34 EPS = 2.3122085E-01
GPU IT = 35 EPS = 2.2372279E-01	CPU IT = 35 EPS = 2.2372279E-01
GPU IT = 36 EPS = 2.1656870E-01	CPU IT = 36 EPS = 2.1656870E-01
GPU IT = 37 EPS = 2.1053367E-01	CPU IT = 37 EPS = 2.1053367E-01
GPU IT = 38 EPS = 2.0475639E-01	CPU IT = 38 EPS = 2.0475639E-01
GPU IT = 39 EPS = 1.9919003E-01	CPU IT = 39 EPS = 1.9919003E-01

Running on GPU...	Running on CPU...
GPU IT = 40 EPS = 1.9381369E-01	CPU IT = 40 EPS = 1.9381369E-01
GPU IT = 41 EPS = 1.8865693E-01	CPU IT = 41 EPS = 1.8865693E-01
GPU IT = 42 EPS = 1.8370365E-01	CPU IT = 42 EPS = 1.8370365E-01
GPU IT = 43 EPS = 1.7892230E-01	CPU IT = 43 EPS = 1.7892230E-01
GPU IT = 44 EPS = 1.7431737E-01	CPU IT = 44 EPS = 1.7431737E-01
GPU IT = 45 EPS = 1.6990997E-01	CPU IT = 45 EPS = 1.6990997E-01
GPU IT = 46 EPS = 1.6610415E-01	CPU IT = 46 EPS = 1.6610415E-01
GPU IT = 47 EPS = 1.6240145E-01	CPU IT = 47 EPS = 1.6240145E-01
GPU IT = 48 EPS = 1.5882880E-01	CPU IT = 48 EPS = 1.5882880E-01
GPU IT = 49 EPS = 1.5536742E-01	CPU IT = 49 EPS = 1.5536742E-01
GPU IT = 50 EPS = 1.5200257E-01	CPU IT = 50 EPS = 1.5200257E-01
GPU IT = 51 EPS = 1.4873235E-01	CPU IT = 51 EPS = 1.4873235E-01
GPU IT = 52 EPS = 1.4558697E-01	CPU IT = 52 EPS = 1.4558697E-01
GPU IT = 53 EPS = 1.4253020E-01	CPU IT = 53 EPS = 1.4253020E-01
GPU IT = 54 EPS = 1.3955924E-01	CPU IT = 54 EPS = 1.3955924E-01
GPU IT = 55 EPS = 1.3667643E-01	CPU IT = 55 EPS = 1.3667643E-01
GPU IT = 56 EPS = 1.3416280E-01	CPU IT = 56 EPS = 1.3416280E-01
GPU IT = 57 EPS = 1.3170609E-01	CPU IT = 57 EPS = 1.3170609E-01
GPU IT = 58 EPS = 1.2930527E-01	CPU IT = 58 EPS = 1.2930527E-01
GPU IT = 59 EPS = 1.2696333E-01	CPU IT = 59 EPS = 1.2696333E-01
GPU IT = 60 EPS = 1.2469535E-01	CPU IT = 60 EPS = 1.2469535E-01
GPU IT = 61 EPS = 1.2247988E-01	CPU IT = 61 EPS = 1.2247988E-01
GPU IT = 62 EPS = 1.2031570E-01	CPU IT = 62 EPS = 1.2031570E-01
GPU IT = 63 EPS = 1.1820155E-01	CPU IT = 63 EPS = 1.1820155E-01
GPU IT = 64 EPS = 1.1615662E-01	CPU IT = 64 EPS = 1.1615662E-01
GPU IT = 65 EPS = 1.1415943E-01	CPU IT = 65 EPS = 1.1415943E-01
GPU IT = 66 EPS = 1.1220850E-01	CPU IT = 66 EPS = 1.1220850E-01
GPU IT = 67 EPS = 1.1046697E-01	CPU IT = 67 EPS = 1.1046697E-01
GPU IT = 68 EPS = 1.0876979E-01	CPU IT = 68 EPS = 1.0876979E-01
GPU IT = 69 EPS = 1.0711144E-01	CPU IT = 69 EPS = 1.0711144E-01

Running on GPU...	Running on CPU...
GPU IT = 70 EPS = 1.0548507E-01	CPU IT = 70 EPS = 1.0548507E-01
GPU IT = 71 EPS = 1.0389012E-01	CPU IT = 71 EPS = 1.0389012E-01
GPU IT = 72 EPS = 1.0232786E-01	CPU IT = 72 EPS = 1.0232786E-01
GPU IT = 73 EPS = 1.0080908E-01	CPU IT = 73 EPS = 1.0080908E-01
GPU IT = 74 EPS = 9.9319922E-02	CPU IT = 74 EPS = 9.9319922E-02
GPU IT = 75 EPS = 9.7859759E-02	CPU IT = 75 EPS = 9.7859759E-02
GPU IT = 76 EPS = 9.6427978E-02	CPU IT = 76 EPS = 9.6427978E-02
GPU IT = 77 EPS = 9.5029531E-02	CPU IT = 77 EPS = 9.5029531E-02
GPU IT = 78 EPS = 9.3665652E-02	CPU IT = 78 EPS = 9.3665652E-02
GPU IT = 79 EPS = 9.2434413E-02	CPU IT = 79 EPS = 9.2434413E-02
GPU IT = 80 EPS = 9.1223224E-02	CPU IT = 80 EPS = 9.1223224E-02
GPU IT = 81 EPS = 9.0031809E-02	CPU IT = 81 EPS = 9.0031809E-02
GPU IT = 82 EPS = 8.8866148E-02	CPU IT = 82 EPS = 8.8866148E-02
GPU IT = 83 EPS = 8.7724653E-02	CPU IT = 83 EPS = 8.7724653E-02
GPU IT = 84 EPS = 8.6602028E-02	CPU IT = 84 EPS = 8.6602028E-02
GPU IT = 85 EPS = 8.5497964E-02	CPU IT = 85 EPS = 8.5497964E-02
GPU IT = 86 EPS = 8.4412147E-02	CPU IT = 86 EPS = 8.4412147E-02
GPU IT = 87 EPS = 8.3349209E-02	CPU IT = 87 EPS = 8.3349209E-02
GPU IT = 88 EPS = 8.2308684E-02	CPU IT = 88 EPS = 8.2308684E-02
GPU IT = 89 EPS = 8.1285425E-02	CPU IT = 89 EPS = 8.1285425E-02
GPU IT = 90 EPS = 8.0279113E-02	CPU IT = 90 EPS = 8.0279113E-02
GPU IT = 91 EPS = 7.9289431E-02	CPU IT = 91 EPS = 7.9289431E-02
GPU IT = 92 EPS = 7.8389276E-02	CPU IT = 92 EPS = 7.8389276E-02
GPU IT = 93 EPS = 7.7507920E-02	CPU IT = 93 EPS = 7.7507920E-02
GPU IT = 94 EPS = 7.6639034E-02	CPU IT = 94 EPS = 7.6639034E-02
GPU IT = 95 EPS = 7.5782459E-02	CPU IT = 95 EPS = 7.5782459E-02
GPU IT = 96 EPS = 7.4938032E-02	CPU IT = 96 EPS = 7.4938032E-02
GPU IT = 97 EPS = 7.4105590E-02	CPU IT = 97 EPS = 7.4105590E-02
GPU IT = 98 EPS = 7.3291357E-02	CPU IT = 98 EPS = 7.3291357E-02
GPU IT = 99 EPS = 7.2489794E-02	CPU IT = 99 EPS = 7.2489794E-02

Running on GPU...	Running on CPU...
GPU IT = 100 EPS = 7.1699681E-02	CPU IT = 100 EPS = 7.1699681E-02
ADI Benchmark Completed.	ADI Benchmark Completed.
Size = 332 x 332 x 332	Size = 332 x 332 x 332
Iterations = 100	Iterations = 100
Time in seconds = 10.784923	Time in seconds = 66.321560
Operation type = double precision	Operation type = double precision
END OF ADI Benchmark	END OF ADI Benchmark

6.Запуск с помощью openmpi

Сбросьте размер сетки (размер=332). Выполнить команду:

```
gcc -O3 -fopenmp adi3d.c -o adi
./adi
```

```
IT =   1   EPS =  1.4939577E+01
IT =   2   EPS =  7.4546828E+00
IT =   3   EPS =  3.7197885E+00
IT =   4   EPS =  2.7841767E+00
IT =   5   EPS =  2.0838841E+00
IT =   6   EPS =  1.6174943E+00
IT =   7   EPS =  1.3835914E+00
IT =   8   EPS =  1.1865898E+00
IT =   9   EPS =  1.0262684E+00
IT =  10   EPS =  8.9621378E-01
IT =  11   EPS =  8.1386743E-01
IT =  12   EPS =  7.4003912E-01
IT =  13   EPS =  6.7499491E-01
IT =  14   EPS =  6.1804058E-01
IT =  15   EPS =  5.6770197E-01
IT =  16   EPS =  5.3173036E-01
IT =  17   EPS =  4.9832553E-01
IT =  18   EPS =  4.6790273E-01
IT =  19   EPS =  4.3984770E-01
IT =  20   EPS =  4.1435740E-01
IT =  21   EPS =  3.9085728E-01
IT =  22   EPS =  3.7277002E-01
```

IT = 23 EPS = 3.5568000E-01
IT = 24 EPS = 3.3966110E-01
IT = 25 EPS = 3.2465039E-01
IT = 26 EPS = 3.1051412E-01
IT = 27 EPS = 2.9735018E-01
IT = 28 EPS = 2.8494276E-01
IT = 29 EPS = 2.7487311E-01
IT = 30 EPS = 2.6529327E-01
IT = 31 EPS = 2.5612042E-01
IT = 32 EPS = 2.4742678E-01
IT = 33 EPS = 2.3914235E-01
IT = 34 EPS = 2.3122085E-01
IT = 35 EPS = 2.2372279E-01
IT = 36 EPS = 2.1656870E-01
IT = 37 EPS = 2.1053367E-01
IT = 38 EPS = 2.0475639E-01
IT = 39 EPS = 1.9919003E-01
IT = 40 EPS = 1.9381369E-01
IT = 41 EPS = 1.8865693E-01
IT = 42 EPS = 1.8370365E-01
IT = 43 EPS = 1.7892230E-01
IT = 44 EPS = 1.7431737E-01
IT = 45 EPS = 1.6990997E-01
IT = 46 EPS = 1.6610415E-01
IT = 47 EPS = 1.6240145E-01
IT = 48 EPS = 1.5882880E-01
IT = 49 EPS = 1.5536742E-01
IT = 50 EPS = 1.5200257E-01
IT = 51 EPS = 1.4873235E-01
IT = 52 EPS = 1.4558697E-01
IT = 53 EPS = 1.4253020E-01
IT = 54 EPS = 1.3955924E-01
IT = 55 EPS = 1.3667643E-01
IT = 56 EPS = 1.3416280E-01
IT = 57 EPS = 1.3170609E-01
IT = 58 EPS = 1.2930527E-01

IT = 59 EPS = 1.2696333E-01
IT = 60 EPS = 1.2469535E-01
IT = 61 EPS = 1.2247988E-01
IT = 62 EPS = 1.2031570E-01
IT = 63 EPS = 1.1820155E-01
IT = 64 EPS = 1.1615662E-01
IT = 65 EPS = 1.1415943E-01
IT = 66 EPS = 1.1220850E-01
IT = 67 EPS = 1.1046697E-01
IT = 68 EPS = 1.0876979E-01
IT = 69 EPS = 1.0711144E-01
IT = 70 EPS = 1.0548507E-01
IT = 71 EPS = 1.0389012E-01
IT = 72 EPS = 1.0232786E-01
IT = 73 EPS = 1.0080908E-01
IT = 74 EPS = 9.9319922E-02
IT = 75 EPS = 9.7859759E-02
IT = 76 EPS = 9.6427978E-02
IT = 77 EPS = 9.5029531E-02
IT = 78 EPS = 9.3665652E-02
IT = 79 EPS = 9.2434413E-02
IT = 80 EPS = 9.1223224E-02
IT = 81 EPS = 9.0031809E-02
IT = 82 EPS = 8.8866148E-02
IT = 83 EPS = 8.7724653E-02
IT = 84 EPS = 8.6602028E-02
IT = 85 EPS = 8.5497964E-02
IT = 86 EPS = 8.4412147E-02
IT = 87 EPS = 8.3349209E-02
IT = 88 EPS = 8.2308684E-02
IT = 89 EPS = 8.1285425E-02
IT = 90 EPS = 8.0279113E-02
IT = 91 EPS = 7.9289431E-02
IT = 92 EPS = 7.8389276E-02
IT = 93 EPS = 7.7507920E-02
IT = 94 EPS = 7.6639034E-02

IT = 95 EPS = 7.5782459E-02

IT = 96 EPS = 7.4938032E-02

IT = 97 EPS = 7.4105590E-02

IT = 98 EPS = 7.3291357E-02

IT = 99 EPS = 7.2489794E-02

IT = 100 EPS = 7.1699681E-02

ADI Benchmark Completed.

Size = 332 x 332 x 332

Iterations = 100

Time in seconds = 7.73

Operation type = double precision

Verification = UNSUCCESSFUL

END OF ADI Benchmark