CATEGORY: DEVELOPER - TOOLS & LIBRARIES - DT05
POSTER P5269
CONTACT NAME Chih-Wei Hsieh: david.hsieh@narlabs.org.tw

GPU TECHNOLOGY CONFERENCE

NCHC *p*CDR
A GPU Implementation Library

Chau-Yi Chou, Chih-Wei Hsieh, Yu-Fen Cheng
National Center for High-performance computing, Taiwan

Introduction

Parallel CDR library (*p*CDR) is a set of code for solving a convection–diffusion–reaction (CDR) scalar transport equation using GPU cards to get correct and precise results in a short time. This equation is practically important because the working equations of many cases fall into this category. The main purpose of the pCDR library is to make program on GPU more easily for scientists. The latest version provides two dimensional CDR scheme to solve real transient and steady state problems.

Method

Consider a two-dimensional convection-diffusion-reaction equation [1] in Eq. (1).

$$u\phi_x + v\phi_y - k\left(\phi_{xx} + \phi_{yy}\right) + c\phi = f \qquad (1)$$

Convection term | Diffusion term | Reaction term | Source term

One can easily find these parameters of Eq.(1) from own PDE, and then they call the following libraries.

- pCDR_init(u, v, k, c, dx, dy, dt, width, height)
- pCDR_free()
- pCDR_SOR_steady(FI, f, tolerance, MAX_STEP, Relax, width, height)
- pCDR_SOR_time(FI, f, dt, Time_step, width, height)
- pCDR_CG_steady(FI, f, tolerance, MAX_STEP, Relax, width, height)
- pCDR_CG_time(FI, f, dt, Time_step, width, height)

One can easily write own GPU program via our template program as shown in Fig. 1. Then, a programmer enjoys the benefit of GPU through his C program only. Fig.2 demonstrates the flowchart of NCHC *p*CDR. A programmer is responsible to the PC side only. However, our libraries handle the GPU computation and data transfer between the CPU and GPU.

```
int main(void) {
  //allocate host memory to receive data
    cudaMallocHost( (void **) &FI, size );
    cudaMallocHost( (void **) &f,  size );

 //set up initial data
   u, v, k, c

  //initial CDR coefficient
   pCDR_init( u, v, k, c, dx, dy, 0.0, width,height);

  //solve Red-Black SOR to steady state
    pCDR_SOR_steady
       ( FI, f, 1.0E-12, MAX_STEP, Relax, width, height );

  //release memory
    pCDR_free();
}
```

Fig. 1 Template program

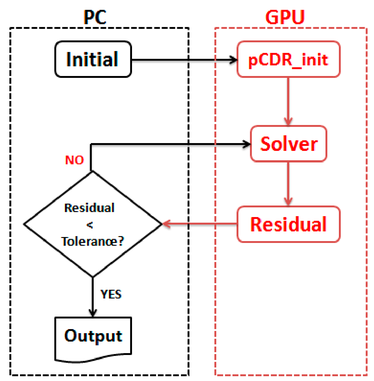

Fig. 2 NCHC pCDR flowchart

Results

Parabolic equation

This study considers 5 Model Problems (MP) performed on AMD Phenom 9850 Quad-Core 2.5GHz (CPU) vs. Nvidia GeForce GTX 280 (GPU).

MP1: $\varphi_t = \nabla^2\varphi$

MP2: $\varphi_t = \nabla^2\varphi - \varphi_x - \varphi_y - \varphi$

MP3: $\varphi_t = \nabla^2\varphi + A(x,y)\varphi_x + B(x,y)\varphi_y - \varphi$

MP4: $\varphi_t = \nabla^2\varphi + \varphi_x + \varphi_y + \varphi + S_1(x,y,t)$

MP5: $\varphi_t = \nabla^2\varphi + x\varphi_x + y\varphi_y - \varphi + S_2(x,y,t)$

where

$A(x,y) = \sin(ax)\cos(ay), \quad B(x,y) = -\cos(ax)\sin(ay)$

$S_1(x,y,t) = (1+xy)\cos(t) - (1+x)(1+y)\sin(t)$

$S_2(x,y,t) = \pi^2(x^2+y^2)e^{-t}\sin(\pi xy) - 2\pi xye^{-t}\cos(\pi xy)$

Fig. 3 shows the 5 MPs speedup. MP1 obtains around 11 times faster than one core-CPU on 400×400 grids.

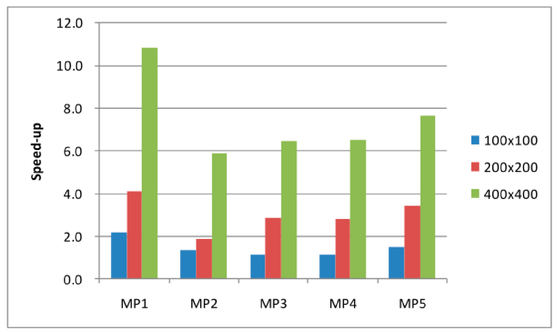

Fig. 3 Model Problems Speedup

Two-phase flow

This problem may requires huge computing resources. Now consider a bubble merging problem with coaxial coalescence as shown in Fig 4.

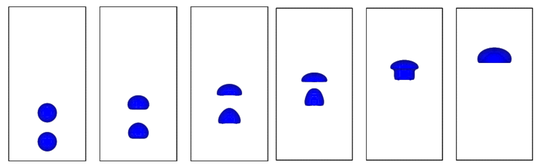

Fig. 4 Merger of two rising bubbles at different non-dimensional times

Fig. 5 shows that Kuo at al. [5] earned 8.53 times faster for solving the pressure Poisson equation (PPE) and 6.25 times faster for solving the two-phase problem than one core-CPU. These results were performed on Intel X5472 (CPU) versus Nvidia Tesla C1060 (GPU).

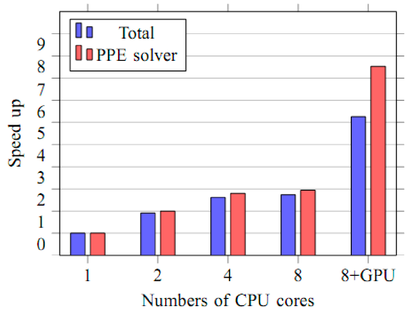

Fig. 5 PPE and two-phase problem speedup

Conclusion

Writing a GPU program is easy to accomplish via this library installed on NCHC platforms.

References

[1] Tony W. H Sheu, at al. (2000), JCP
[2] Chih-Wei Hsieh, at al. (2010), ISPA10
[3] Chih-Wei Hsieh, at al. (2010), PDPTA10
[4] Sheng-Hsiu Kuo, at al. (2010), HPCTA10
[5] Sheng-Hsiu Kuo, at al. (2010), ISSN: 2010-4065

Contact:

Chau-Yi Chou
cychou@nchc.narl.org.tw

NARLabs