

Mesh11 Distributed Mesh

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1. 项目目的

参考课件和项目代码中的提示, 修改程序中的错误, 并实现并行化。相关课件截图如下:

- Debug Program.cpp as a sequential program 先按顺序程序调试
- Run it as a parallel program 可运行且基本正确后按并行程序运行。
 - MPIEXEC -n 8 mmm.exe
- Build the distributed mesh 再考虑分布 Mesh 的划分调整

Solutions for the Problems

0. Global Mesh is allocated for all processes

1. Renumbering (reordering) the global mesh first, then partitioning
2. Renumbering for submesh in each process via communication

2. 为实现目的存在的各种技术问题

理解 mesh 的实现方法

熟练掌握 MPI 并行编程模型

划分 mesh, 使得每个进程都能拿到自己所需的所有数据

3. 用什么算法、数据结构、语言机制解决这些问题

选用课件中的第 1 种, 主要思路按照如下思路实现:

```
double* new_x = (double*)malloc(4 * g_ncell * 3 * sizeof(double));

for (int i = 0; i < g_ncell; i++) { ////////////
    memcpy(new_x + (4 * i + 0) * 3, g_x + (g_cell[4 * i + 0]) * 3, 3 * sizeof(double));
    memcpy(new_x + (4 * i + 1) * 3, g_x + (g_cell[4 * i + 1]) * 3, 3 * sizeof(double));
    memcpy(new_x + (4 * i + 2) * 3, g_x + (g_cell[4 * i + 2]) * 3, 3 * sizeof(double));
    memcpy(new_x + (4 * i + 3) * 3, g_x + (g_cell[4 * i + 3]) * 3, 3 * sizeof(double));
}

memcpy(g_x, new_x, 4 * g_ncell * 3 * sizeof(double));

...

free(new_x);
```

4. 对应的程序框架和实现代码

我主要探索了 area 计算部分的并行化，先创建 new_x 作为 renumber 后的 g_x 数组，填充好其数据后，再分配到各个进程的 x_for_area 数组中，计算好结果存到 q 和 adt 数组后，后续步骤再只用 0 号进程进行计算。

```
new_x = (double*)malloc(4 * g_ncell * 3 * sizeof(double));
for (int i = 0; i < g_ncell; i++) { ////////////
    memcpy(new_x + (4 * i + 0) * 3, g_x + (g_cell[4 * i + 0]) * 3, 3 * sizeof(double));
    memcpy(new_x + (4 * i + 1) * 3, g_x + (g_cell[4 * i + 1]) * 3, 3 * sizeof(double));
    memcpy(new_x + (4 * i + 2) * 3, g_x + (g_cell[4 * i + 2]) * 3, 3 * sizeof(double));
    memcpy(new_x + (4 * i + 3) * 3, g_x + (g_cell[4 * i + 3]) * 3, 3 * sizeof(double));
}
```

```
MPI_Barrier(MPI_COMM_WORLD);

for (int k = 0; k < 2; k++) {
    for (int i = 0; i < ncell; i++) { ////////////
        area(
            x_for_area + (4 * i) * 3,
            x_for_area + (4 * i + 1) * 3,
            x_for_area + (4 * i + 2) * 3,
            x_for_area + (4 * i + 3) * 3,
            q + 4 * i,
            adt + i);
    }
    MPI_Barrier(MPI_COMM_WORLD);
    gather_double_array(g_q, q, comm_size, g_ncell, ncell, 4);
    gather_double_array(g_adt, adt, comm_size, g_ncell, ncell, 1);
}
```

为了保持并行化运行和串行程序运行结果一样，还需要修正这行代码：

```
rms = sqrt(rms / (double)g_ncell);
```

5. 实验结果和结论



```
Microsoft Visual Studio 调试控制台
initialising flow field
Number of nodes, cells, edges, bedges on process 0 = 180901, 180000, 359300, 1400
Writing OutputSimulation to ASCII file: new_grid.vtk
Local 1 2.88246e-03
ROOT: Total residual 2.88246e-03
1 tests run
There were no test failures
Your grade is 0
请按任意键继续. . .

C:\Users\豹豹\OneDrive - 中山大学\大三上\程序设计\Mesh11\Mesh11.DistributedMesh\Debug\Mesh11-DistributedMesh.exe (进程 28192)已退出，代码为 0。
要在调试停止时自动关闭控制台，请启用“工具”->“选项”->“调试”->“调试停止时自动关闭控制台”。
按任意键关闭此窗口. . .
```

如图所示，串行程序的代码运行结果正确。以下是用 mpiexec 并行化运行的结果：

```
命令提示符 - mpiexec -n 2 Mesh11-DistributedMesh

job aborted:
[ranks] message

[0] job terminated by the user
[1] terminated

---- error analysis ----

[0] on DESKTOP-3JQPIBS
ctrl-c was hit. job aborted by the user.

---- error analysis ----

C:\Users\豹豹\OneDrive - 中山大学\大三上\程序设计\Mesh11\Mesh11.DistributedMesh>mpiexec -n 2 Mesh11-DistributedMesh
initialising flow field
Number of nodes, cells, edges, bedges on process 0 = 90451, 90000, 179650, 700
initialising flow field
Number of nodes, cells, edges, bedges on process 1 = 90450, 90000, 179650, 700
Writing OutputSimulation to ASCII file: new_grid.vtk
Local 1 2.88246e-03
ROOT: Total residual 2.88246e-03
1 tests run
There were no test failures
Your grade is 0
1 tests run
There were no test failures
Your grade is 0
请按任意键继续. . .

命令提示符 - mpiexec -n 4 Mesh11-DistributedMesh

C:\Users\豹豹\OneDrive - 中山大学\大三上\程序设计\Mesh11\Mesh11.DistributedMesh>mpiexec -n 4 Mesh11-DistributedMesh
initialising flow field
Number of nodes, cells, edges, bedges on process 0 = 45226, 45000, 89825, 350
initialising flow field
Number of nodes, cells, edges, bedges on process 1 = 45225, 45000, 89825, 350
initialising flow field
Number of nodes, cells, edges, bedges on process 3 = 45225, 45000, 89825, 350
initialising flow field
Number of nodes, cells, edges, bedges on process 2 = 45225, 45000, 89825, 350
Writing OutputSimulation to ASCII file: new_grid.vtk
Local 1 2.88246e-03
ROOT: Total residual 2.88246e-03
1 tests run
1 tests run
There were no test failures
There were no test failures
Your grade is 0
Your grade is 0
1 tests run
There were no test failures
Your grade is 0
1 tests run
There were no test failures
Your grade is 0
请按任意键继续. . .
请按任意键继续. . .
请按任意键继续. . .
请按任意键继续. . .
```

如图所示，并程序运行结果正确。