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A new parallel meshing technique integrated into the conformal FDTD method for solving complex electromagnetic problems

Keywords: FDTD, Meshing, Parallel, Function language, Surface current distribution

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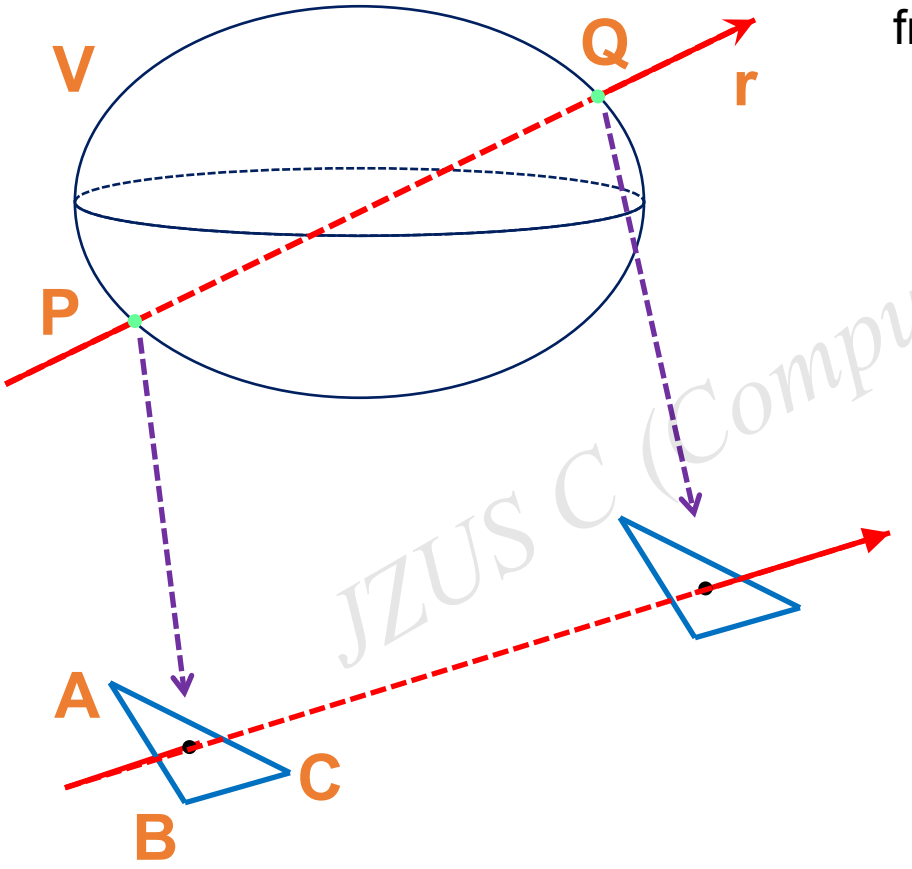
Introduction

- Meshing is an important pre-process of FDTD simulation
- Parallel technique has been widely used in FDTD simulation process, however, traditional languages such as C and Fortran are not efficient for parallel computation
- Traditional origin-searching based meshing algorithm will cause error in some extreme cases, what is more, this algorithm cannot be easily high efficiently parallelized

Meshing algorithm



P is the projection point to a 2D space from an arbitrary position in model

$$(x, y) = u \cdot (x_1, y_1) + v \cdot (x_2, y_2) + w \cdot (x_3, y_3)$$

$$\left.\begin{aligned} u &= \frac{(x_2y_3 + x_3y + xy_2 - x_2y - xy_3 - x_3y_2)}{(x_2y_3 + x_3y_1 + x_1y_2 - x_2y_1 - x_1y_3 - x_3y_2)} \\ v &= \frac{(xy_3 + x_3y_1 + x_1y - xy_1 - x_1y_3 - x_3y)}{(x_2y_3 + x_3y_1 + x_1y_2 - x_2y_1 - x_1y_3 - x_3y_2)} \\ w &= \frac{(x_2y + xy_1 + x_1y_2 - x_2y_1 - x_1y - xy_2)}{(x_2y_3 + x_3y_1 + x_1y_2 - x_2y_1 - x_1y_3 - x_3y_2)} \end{aligned}\right\}$$

$$\cos\theta = \boldsymbol{n}_{\mathrm{r}} \cdot \boldsymbol{n}$$

A(x_1, y_1), B(x_2, y_2) and C(x_3, y_3) are vertexes for a triangle

Function language based parallelization

- Traditional open MP-based parallelization

```
#pragma parallel for
for (i = iBegin; i < iEnd; i++)
  for (j = jBegin; j < jEnd; j++)
    for (k = jBegin; k < jEnd; k++)
      // Some iteration code here
```

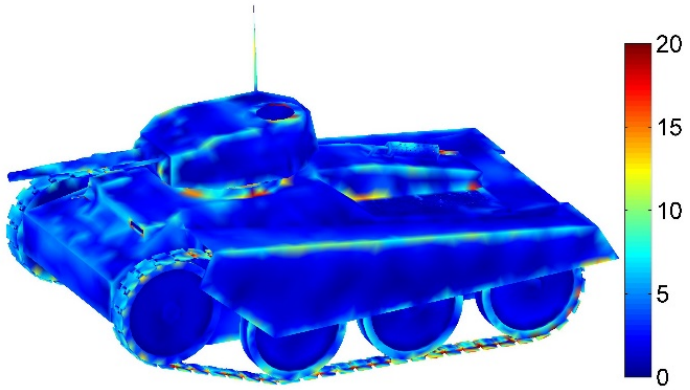
Work only on the 1st layer loop

- Function language based parallelization

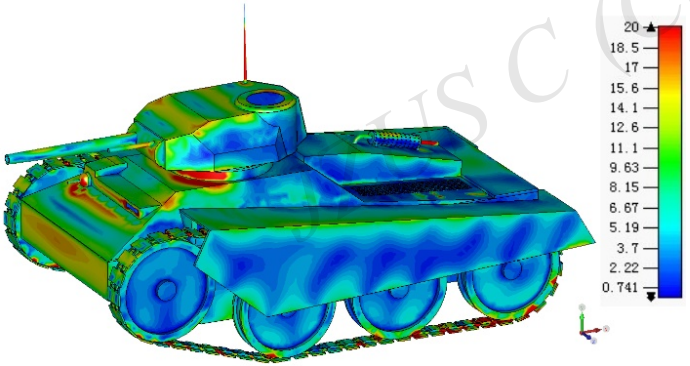
```
let iterFunc grids = Seq.iter IterationFunc grids
do Array.Parallel.iter gridsArray iterFunc
```

More easily to be parallelized (only one word ‘Prallel’ is needed) and work on all grids

Simulation results

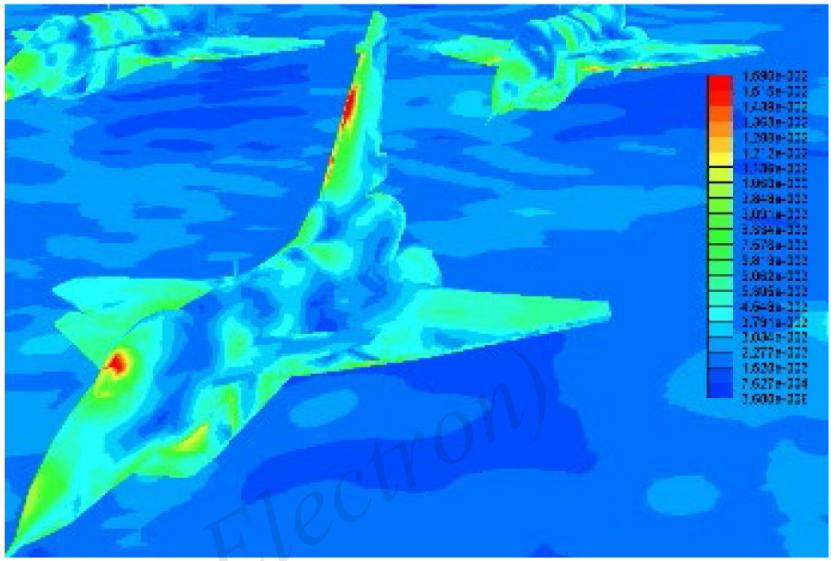


(a)



(b)

Surface current of a Tank model
(a): Our algorithm; (b): The CST software



Surface current of a large aircraft carrier platform with 20 aircrafts

Domain scale	328m×72m×59m	
Mesh size	0.1m×0.1m×0.1m	
Target frequency	300MHz	
Memory	about 80GB	
CPU	48 cores	Single core
Run time	About 30 Hours	More than one week (unfinished)

The problem scale and simulation cost

Conclusions

- A ray-tracing based meshing algorithm is implemented with function language based parallelization technique
- The parallel efficiency can reach as high as 60% on a computer with four CPU cores
- Integrated with high-order conformal FDTD algorithm, the surface current distributions for a tank and aircraft model are successfully extracted, and the accuracy is comparable with CST and FEKO software