Electromagnetic Field Analysis by using Parallel Processing Based on OpenMP

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Abstract— Recently, numerical analysis of electromagnetic field can be performed on high performance PCs. However, improvement of CPU operation frequency is becoming saturate. In order to speed up the calculation, multi-core CPU system is paid attention and it has been used in high performance PC. In this paper, a parallelization using multi-threads on SMP (Symmetric Multiple Processor) for a finite element analysis using hexahedral edge element is investigated.

I. INTRODUCTION

Numerical methods for the electromagnetic field analysis by the finite element method and the integral equation method are implemented in the design of electrical and electronic equipments by speeding up PC. The speed-up of PC has been achieved by improving the operation frequency of CPU so far. However, the improvement of the operation frequency of CPU has reached the limit. The parallel processing by multi-core CPU is paid attention as a method of speeding-up new PC. However, the effect of speed-up by multi-core CPU is not achieved by existing sequential processing programs. In this paper, the availability of the parallel processing is investigated by parallelization of an electromagnetic field analysis program with multi-thread on the SMP system.

II. PARALLELIZATION OF ELECTROMAGNETIC FIELD ANALYSIS

In this paper, the multi-thread parallelization of the setting up coefficient matrix of the finite element method with the hexahedral edge element and the ICCG method [1] was done with OpenMP [2]. The model of the TEAM Workshop Problem 7 is used for investigation of the parallelization. It is important to parallelize the outer loop in order to achieve a high parallelization effect with multi-thread. The process of the setting up coefficient matrix can be easily parallelized the outer loop because there is no dependency of the computation. The iteration loop of the ICCG method can not be parallelized because of its algorithm. Therefore, only the processes of the products of vector and matrix in inner loops of the ICCG iteration were parallelized so that the overhead of the thread generation and the disposal process decrease.

III. PARALLELIZATION EFFECT BY MULTI-THREAD

The processing time of the setting up coefficient matrix and the ICCG method is indicated in Table I. In the setting up coefficient matrix, a high parallelization effect is achieved with the SMP systems of the P3 (Pentium III 933MHz x 2) and the PPC970 (PowerPC 970 2.5GHz x 2). A parallelization effect over the theoretical value was achieved by dual threads, because the processing performance of the sequential-processing code decreases by the load balance between two CPUs which is a function of OS. Figure 1 shows the processing times of the setting up coefficient matrix and the ICCG method. The graph shows a relative rate of each system. The high parallelization effects are achieved in the process of the setting up coefficient matrix for the P3 and the PPC970. In the ICCG method, the parallelization effect of the PPC970 is higher than that of the P3.

IV. CONCLUSION

The parallelization effects of two PC systems with OpenMP for the setting up coefficient matrix and the ICCG method are confirmed. A parallelization effect of the ICCG method will be improved as a problem in the future.

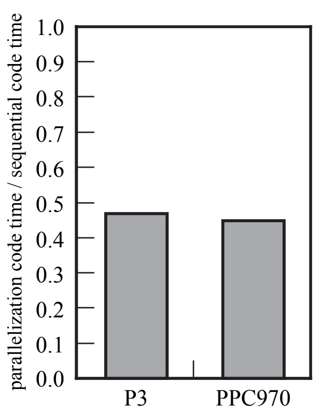
V. REFERENCES

[1] Masatake Mori, "FORTRAN77 Numerical Calculation Programming (in Japanese)", Iwanami Shoten, 1986.
[2] The OpenMP Application Program Interface: http://www.openmp.org/

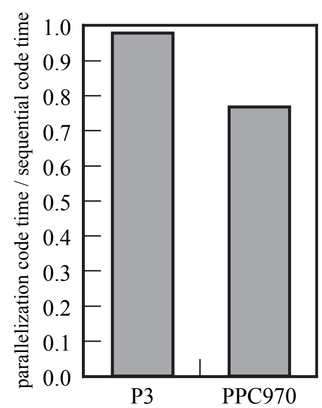
TABLE I
PROCESSING TIMES OF SETTING UP COEFFICIENT MATRIX AND THE ICCG METHOD.

		Sequential code		OpenMP parallelization code	
		time (sec)	iteration steps	time (sec)	iteration steps
Setting up coefficient matrix	P3	737.0	-	337.3	-
	PPC970	320.9	-	140.8	-
ICCG method	P3	46.9	347	45.6	363
	PPC970	12.4	374	9.5	357

elements (hexahedra): 7488, unknowns : 24925



(a) Setting up coefficient matrix.



(b) ICCG method.

Fig. 1. Parallelization effect of electromagnetic field analysis.

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