IMPLEMENTATION OF THE DISTRIBUTED PARALLEL PROGRAM FOR GEOID HEIGHTS COMPUTATION USING MPI AND OPENMP

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Commission IV, WG IV/5

KEY WORDS: Distributed parallel computing, Geoid heights computation, MPI, OpenMP, Diskless-based PC Cluster

ABSTRACT:

Much research have been carried out using optimization algorithms for developing high-performance program, under the parallel computing environment with the evolution of the computer hardware technology such as dual-core processor and so on. Then, the studies by the parallel computing in geodesy and surveying fields are not so many. The present study aims to reduce running time for the geoid heights computation and carrying out least-squares collocation to improve its accuracy using distributed parallel technology. A distributed parallel program was developed in which a multi-core CPU-based PC cluster was adopted using MPI and OpenMP library. Geoid heights were calculated by the spherical harmonic analysis using the earth geopotential model of the National Geospatial-Intelligence Agency(2008). The geoid heights around the Korean Peninsula were calculated and tested in diskless-based PC cluster environment. As results, for the computing geoid heights by a earth geopotential model, the distributed parallel program was confirmed more effective to reduce the computational time compared to the sequential program.

1. INTRODUCTION

These days, global navigation satellite systems (GNSS) have been widely used and geoid is a very important element which makes it possible to determine orthometric height using GNSS positioning. Moreover, many countries have continued to make efforts to develop their own high-precision geoid model (Chandler and Merry, 2010; Kuroishi et al., 2002; Roman et al. 2009; Toth et al. 2000)

Since global geopotential models (GGMs) well expresses long wavelength component of the Earth's gravity field (Daho et al. 2008; Krynski and Lyszkowicz 2006), they not only provide basis for the gravity field to develop high-precision geoid model but also have important meanings as reference surface for calculating a local geoid (Bae et al., 2011; Dawod et al., 2010). In addition, countries which are difficult to develop geoid models have been using GGMs for rough calculation of geoid heights (or undulations) and gravity anomaly through spherical harmonic analysis (SHA) (Lee et al., 2008)

Geopotential data that is recently observed by GRACE satellite has contributed to more precise GGMs development and especially these (geopotential data) have been greatly contributed to development of Earth gravitational model 2008 (EGM2008). EGM2008 is complete to degree and order 2,159 and includes additional spherical harmonic coefficients extending to degree 2,190 and order 2,159 (Pavlis et al., 2008; Pavlis et al., 2012).

Moreover, because GGMs-derived geoid heights are referred to a global vertical datum and these are fitted with a local vertical datum by GPS/levelling-derived geoid heights, the accuracy of these (geoid heights) could be enhanced. For this purpose, least-squares collocation (LSC) method is widely used (Kotsakis et al., 2008; Lee et al., 2008).

As mentioned above, although SHA and LSC are mostly used to evaluate accuracy and suitability of ultra-high degree geopotential models for certain local areas or countries, they all contain time-consuming problem. In geoscience simulations, to solve this problem, resources are distributed parallel computation is getting popularity to reduce data processing time. This paper is intended to carry out LSC to fit ultra-high degree SHA by EGM2008 using distributed parallel computation on PC cluster and present its performance evaluation.

2. DATA

2.1 EGM2008 geopotential model

EGM2008 is a spherical harmonic model of the Earth's gravitational potential, developed by U.S. National Geospatial-Intelligence Agency (NGA) (Lemoine, 1996; Pavlis et al., 2008; Pavlis et al., 2012).

EGM2008 is the first-ever global model that is capable of resolving the Earth's gravity field beyond spherical harmonic degree 2000. EGM96 that is a widely used GGM has spatial resolution of 30 arc minutes whereas EGM2008 is a high-resolution GGM of Earth's gravity field that allows computation of geoid heights down to a resolution of 5 arc minutes (Dawod et al., 2010; Pavlis et al. 2008).

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