Abstract of Doctoral Thesis

Title：MODELING OF GNSS REGIONAL IONOSPHERIC DELAYS BY THE SPHERICAL CAP HARMONIC ANALYSIS

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This thesis describes the modeling of Japanese regional ionospheric delays for global navigation satellites system (GNSS) positioning by using the spherical cap harmonic (SCH) analysis. The highly accurate correction of ionospheric delays is realized for high accuracy GNSS positioning.

First, the mathematical models of a code pseudorange and carrier phase measurements which are basic equations for positioning are derived. In this study, the measurements are obtained by the dual frequencies of L1 and L2 bands. The fundamental measurements of L1 and L2 carrier phases and code pseudoranges based on C/A and P(Y) codes are formulated using GNSS regression (GR) models. In this thesis, ionospheric delays are analyzed using the GR models to develop ionospheric delay models.

Next, the methods of modeling ionospheric delays are described. The observation equations are derived to estimate ionospheric delays by applying the geometry-free combination. An ionospheric delay is proportional to total electron content (TEC) along a signal path. For this reason, the vertical components of TEC (VTEC) are treated as a function of a latitude and longitude and are modeled by a two-dimensional Taylor (2DT) expansion, spherical harmonic (SH) function and SCH analysis. A single-layer model, which assumes an ionosphere to be a single spherical shell, is generally used for ionospheric delay models. In addition, a multi-layer model combining single-layer models is also considered.

Finally, the ionospheric model prediction is discussed. The proposed models cannot be applied to real-time positioning because they are post-processing models. To solve this

problem, prediction methods are proposed by applying autoregressive (AR) and vector autoregressive (VAR) models.

In the experiments, regional GNSS data were obtained from the GNSS Earth Observation Network (GEONET) of the Geospatial Information Authority of Japan (GSI). The regional ionospheric VTEC values were modeled using 2DT expansion, SH function and SCH analysis. The correction accuracy of the developed models was evaluated by comparing positioning accuracy with the Klobuchar model and the global ionosphere map (GIM) provided by the International GNSS Service (IGS). From the experimental results, the effectiveness of the single-layer SCH models is shown for regional ionospheric delays. The predictions of the AR model can then effectively be applied to real-time positioning.