Proceedings of a pre-conference workshop of the 27th International Cartographic Conference:
Spatial data infrastructures, standards, open source and open data for geospatial (SDI-Open 2015)
20-21 August 2015, Brazilian Institute of Geography and Statistics (IBGE), Rio de Janeiro, Brazil

Conceptual data modeling in geospatial information technology tool kit (gittok)

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Keywords: teaching assistance tool, geospatial information technology, geospatial information standards, conceptual data modeling

1. Introduction

Capacity building of people who require the knowledge of geospatial information technology (GIT) is a pressing problem for the development and the improvement of a spatial data infrastructure (SDI). Meanwhile, geospatial information standards (GI-Standards) are adopted as one of the knowledge units of geospatial information science and technology (GIS&T) Body of Knowledge proposed by countries such as the USA, Europe, South Africa, and Japan. However, at least in Japan, there is little education on GIT based on GI-Standards. Often, in an introductory course on GIS, students learn geo-data processing through exercises using a general-purpose GIS. The merit of this is that students become familiar with how to use GIS. Meanwhile, currently, people are becoming familiar with geospatial data processing, mainly because the availability of software systems and hardware such as global positioning systems, unmanned aerial vehicles and mobile devices is increasing. In addition, the open data policies promoted by governments, and the use of free and open-source software are becoming widespread. These facts encourage the enhancements to ubiquitous information services, appearance of volunteered geographic information (VGI), and SDI. For example, Cooper et al. (2011) have pointed out that the increasing costs of official mapping programs coupled with the availability of high volumes of quality and up-to-date VGI have led to the integration of VGI into some SDIs.

However, improvement of geo-data sharing is impossible without engineers who have the knowledge of GIT and GI-Standards. GIT is defined as an information technology for the modeling, acquisition, management, analysis, exchange, and representation of geospatial information (Ota 2012). According to the scope of ISO/TC 211, standardization for geospatial information aims to establish a structured set of standards for information concerning objects or phenomena that are associated with a location relative to the Earth. In order to teach the underlying technology of SDI, teaching materials on GIT and GI-Standards need to be prepared. However, software tools that meet these conditions are very few. This was the reason to develop the geospatial information technology tool kit (gittok, pronounced: jee-tock, ʤiːtɒk). Gittok is a free open-source "all-in-one" software tool that assists students learning about "what is GIT" on the basis of GI-Standards (Ota 2015). Gittok and the related teaching materials are available at <http://stinfodesign.net/gittok/>. Source code is uploaded on <https://github.com/ stinfodesign/gittok>.

Gittok includes a module to design the application schema (AS) according to the gittok general feature model (GFM). Data acquisition, analysis, and mapping directly use the AS in gittok. This extended abstract focuses on conceptual data modeling after a brief introduction to gittok, and finally, the results of the first college-level course on the introduction to GIT based on GI-Standards at Chuo University, Japan, will be reported.

2. Introduction to Gittok

Gittok consists of six modules to realize the knowledge areas in the pages displayed on the screen. These areas are modeling, acquisition, management, analysis, exchange, and representation (Figure 1).

Gittok was implemented on the basis of the simplified profiles of GI-Standards to maintain the harmonization among the six modules.

Conceptual data modeling is a conceptualization from the universe of discourse to the AS that describes the feature types and their relationships. Gittok enables the modeling by using a module called "Modeler." Students can generate ASs including definitions of feature types and association types. Modeler uses a simplified version of GFM provided by ISO 19109. Modeler also refers to ISO 19103, ISO 19107, and ISO 19155 for the definition of simple data types, geometric primitives, and place identifiers including postal address and URL.

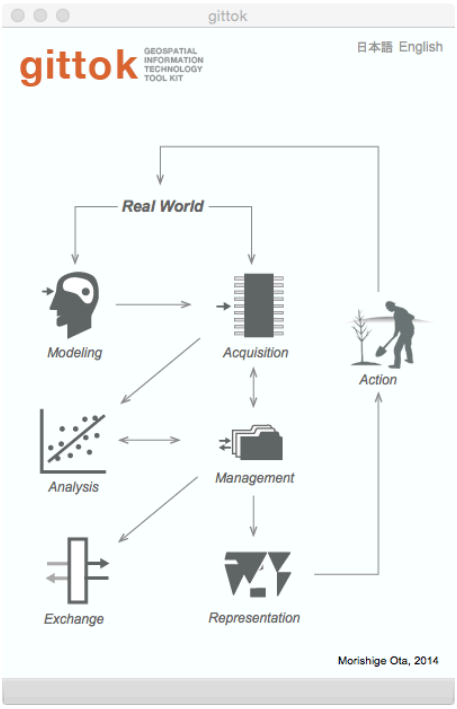

Figure 1. Title page of gittok.

Acquisition is a transformation from the real-world phenomena into a geospatial dataset called a "kit." Gittok is not a general-purpose GIS, and therefore, it is impossible to use various acquisition methods. However, students can practice map digitizing to capture geometric attributes with topology and can embed images, movies, audio files, URLs, and other thematic data into feature instances through the software module called "Editor." Gittok refers to ISO 19111 for the definition of coordinate reference systems and ISO 19118 for designing the instance model.

Management is a process of dealing with kit files. Gittok manages kit files through "Manager," where the students can store and query kit files. Additional procedures such as updating, analysis, exchange, and representation can be practiced through "Manager." Gittok refers to ISO 19115 for the schematization of the simple metadata.

Geo-data analysis derives the analysis result from a kit file. Gittok provides a limited number of operations applying basic computational geometry in a module called "Analyst." However, the author recommends that teachers and students add additional analysis tools, because the last purpose of this education is the capacity building of engineers who can contribute to improve SDIs.

A **Data exchange** module called "Exchanger" encodes and decodes XML data such as an AS, a kit, metadata, and a set of parameters defining the coordinate reference system. ISO 19136 affects gittok in terms of the rules for describing XML documents.

Finally, **representation** uses a portrayal schema that specifies how to design maps. A module called "Cartographer" enables the students to design interactive maps by using a kit file and a portrayal schema. The author has referred to ISO 19117 in order to design the portrayal architecture of gittok.

3. Conceptual Data Modeling in Gittok

GFM establishes a basis for the definition of features and their relationships. AS is a conceptual schema for data required by one or more applications (ISO 19101-1) created in compliance with the GFM.

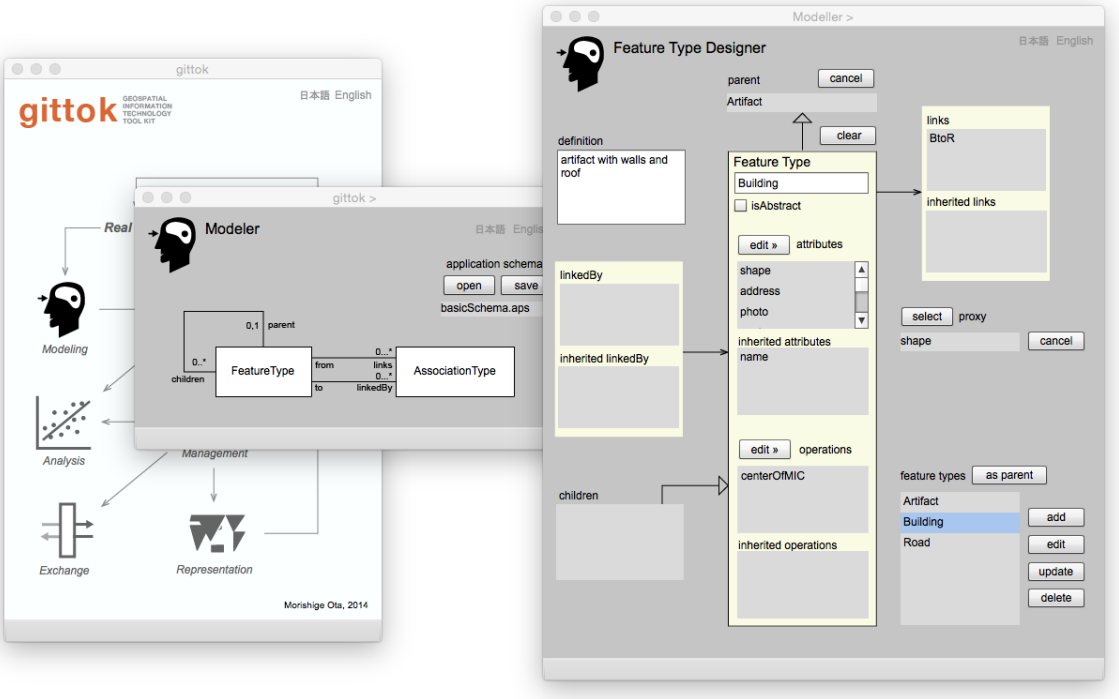

Figure 2. Modeler and a page for feature type designing.

According to ISO 19109, GFM distinguishes four aspects of defining feature types: the definitions or description used for grouping features into types, the attributes associated with each type, the relationships among the types, and the behavior of the features (Figure 2). Behavior is an operation procedure associated with a feature.

Gittok GFM is a subset of ISO GFM. First, gittok GFM does not define the GF_Constrain type for the restriction of attribute values. Because instantiation of this class provides a high degree of freedom and investigation is required before the implementation. For example, it

can be an independent part in the data product specification. Second, an association type in gittok GFM does not inherit a feature type to make the association type simpler. Finally, the inheritance relation type is not defined in gittok GFM. Instead, inheritance is defined as a relationship between different feature types. Child features inherit the properties of parent feature by this relationship.

Gittok GFM is a practical meta-model of the AS to be used as a specification for the data acquisition. However, currently, only a few software programs directly apply the AS to data acquisition. This is attributed to the fact that an automatic translation from the AS into the data structure of RDBS is difficult because of the so-called impedance mismatch. This is one of the reasons that gittok does not use DBS; instead, it enables users to obtain geospatial data in accordance with an AS produced by "Modeler."

4. Practice of education

The author conducted a semester-long course for 10 senior-year undergraduate students at Chuo University in Tokyo, Japan, in 2014. The program covered the design of an AS, geo-data acquisition, data management, spatial analysis, XML document encoding, and design of an interactive thematic map. Gittok was used each time after the preliminary explanation and introduction of the underlying knowledge such as that of GI-Standards. From the results of the final exercise, the author confirmed that it is possible to provide a formal introduction to GIT based on GI-Standards in the form of a college-level course to new students.

5. Conclusion

Gittok is educational support software of GIT based on GI-Standards. Gittok consists of six modules to introduce GIT; for instance, "Modeler" is a module to design the AS according to the gittok GFM, a practical profile of ISO GFM. Gittok was used in a semester-long course for undergraduate students and it was confirmed that it is possible to provide a formal introduction to GIT based on GI-Standards in the form of a college-level course.

Acknowledgements

I am grateful to the members of the GIT group (Leader: Koichi Kubota, Chuo University) established under the project supported by Grant-in-Aid for Scientific Research (A), Ministry of Education, Culture, Sports, Science and Technology (Project number: 21240075. Project leader: Yasushi Asami, The University of Tokyo), the Geospatial Information Authority of Japan, and the many people who provided their kind advice and made this study possible.

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