HARPS Challenges to BIG-PV Power Systems

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This talk presents the outline and several current research topics of the research project "System Theory for Harmonized Power System Control Based on Photovoltaic Power Prediction (HARPS)," supported by the EMS CREST research program of JST (April 2015-March 2020).

According to "Long-term Energy Supply and Demand Outlook" proposed by METI in July 2015, the target in 2030 of the photovoltaic (PV) power installed capacity in Japan is 7% of the total electric energy in the entire Japan, which corresponds to about 64GW. This enables us to reduce CO_2 emission gaining momentum. However, the PV power includes unpredictable large fluctuations. Thus, it is required to develop new control technologies to achieve a stable electric power supply using PV generation forecasts. In addition, there are needs to fundamentally review frameworks of the system structure of the whole power system to achieve the supply and demand balance. Electric power control systems are going to be renewed along with various kinds of new technologies such as Virtual Power Plant and Real-time Market after the deregulation of electricity and the unbundling of electricity generation and transmission.

The main purpose of this research project is to develop a system theory of next generation power system control in order to achieve a harmonized power supply under large penetration of photovoltaic (PV) power systems enabling PV introduction of 102GW, and further towards PV introduction of 330GW. In particular, this project aims to develop a power system control framework and methodology, fully exploiting PV/demand power prediction, and focusing on, in addition to system operation and user layers, functions and properties of a middle layer consisting of various kinds of power aggregators such as demand-response aggregators, electricity-trade balancing groups, and cooperative electric power converters, in other words, the main topics are as follows:

(i) Electric Power System Design: a system design theory composed of supply layer, middle layer, and consumer layer

(ii) Prediction Technology: a PV generation prediction technology adapted to power system control techniques that achieves a stable power supply

(iii) Control Technology: a power system control theory and technology to realize a harmonized stable power supply from the perspectives of fairness and comfort as well as the economics and environmental friendliness, by fully exploiting PV generation predictions.

See http://harps-crest.jpn.org/ for the further details on this project.

Keywords: Photovoltaic power, Power System Control

Enhancement of Segment Tracing Algorithm for lineament extraction based on topographic characteristics

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The Segment Tracing Algorithm (STA) is one of the effective methods to automatically extract lineament from the satellite image and shaded relief image generated from DEM. This algorithm can extract the lineament by extraction and connection of line elements. The line element is the cell having linear topographic feathers which is recognized by the change of the reflection intensity. Because the shaded relief image and the satellite image depend on the direction that irradiates light, extraction capability varies according to the lineament direction. The aim of this study is to extract lineaments from topographic characteristics based on DEM without using reflection intensity. The extraction processing of the lineament is as follows: (1) calculation of the normal vector of the topographic surface in each cell of DEM, (2) decision of continuous direction, (3) extraction of line elements, (4) connection of line elements, and (5) rearranging for the line. This method of each processing enhanced it, and optimized it.

Keywords: lineament, STA, DEM, topographic characteristics

Improvement of accuracy of metal content modeling using geostatistics in consideration of geological information

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Because most geological data are obtained at irregularly spaced points, a 3D modeling method is indispensable to estimate spatial distribution of value or category. In addition, geological data are multivariate that have several variables at the same point in many cases. For this data type, multivariate geostatistics has been widely used which assigns the optimal weights to each datum through a spatial correlation structure, termed cross-semivariogram. Kriging is a spatial estimator founded on this principle. Correlation of a variable pair naturally differs with the selected variables and also, geological type: the correlation of a pair may be strong in a certain geological type, but weak in the other types. This nominal information such as the geological type is difficult to be considered in multivariate geostatistics. For this problem, this study applies principal component analysis (PCA) to incorporate the dependence of data-pair correlation on geological type and decorrelate it by the orthogonal transformation, which can increase the estimation accuracy and decrease the calculation amount by requiring the calculation of only semivariogram of the principal components.

This idea is tested to a problem of metal content modeling over a deposit, because its accurate estimation is essential to reserve assessment and ore body characterization and moreover, contribute to resource exploration of the same deposit type. Matsumine and Fukazawa mines, typical large kuroko deposits in the Hokuroku district, Akita Pref., northern Japan, are selected for a case study. Kuroko is a Japanese term for massive, compact black-ore mainly composed of sphalerite, galena, and pyrite. Kuroko deposits were originated from felsic to intermediate submarine volcanic activity (e.g. Yamada and Yoshida, 2013). The metal contents of Cu, Zn, and Pb for both the mines and Au and Ag for the Fukazawa mine in the drilling cores were used for the data analyses.

The number of drillholes are Matsumine: 77 and Fukazawa: 58 and the target areas are 420 m ×940 m (along the horizontal) ×390 m (along the vertical) and 1100 m ×2400 m ×450 m, respectively. Main rock types are selected from the geological columns. PCA is applied to a dataset composed of the metal contents and binary data of the geological type: 1 for the presence of a geological type and 0 for the other types. The principal components are used for semivariogram modeling and kriging calculation, and by the inverse transformation of PCA, metal contents and geological type can be given to each grid point. This method, termed PCA-kriging (PCAK) incorporates the information on the spatial correlation structure of data pair and its dependence on geological type into the spatial modeling. The estimation result of metal content distribution is compared with the results of ordinary kriging (OK) and co-kriging (CK).

Common to both the mines and all metals, the CK results are mostly underestimate and, despite the similar distribution patters of OK and PCAK, the PCAK result contains less smoothing effect. This difference is particularly remarkable in a large content range, which causes large difference in reserve assessment between OK and PCAK, such as double amounts of Cu and Pb by PCAK than the OK amount. Another PCAK advantage is to draw a geological model using the geological types output, which is apparently harmonious with the preceding model. Overlay of the high content zones upon the geological

model is revealed to be effective to detection of the ore-solution paths and interpretation of the deposit-generation process.

References
Yamada, R. and Yoshida, T. (2013) Kuroko deposits and related back-arc volcanism in the Hokuroku district, *Jour. Geol. Soc. Japan*, v. 119, Supplement, p. 168-179.

Keywords: Principal component analysis, kriging, Kuroko, geological model, ore-solution path

- MGI30-03 -

Cloud tracking method for the Venus satellite Akatsuki

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We present the novel cloud tracking method developed to estimate horizontal winds from the images obtained by the Venus orbiter Akatsuki. The method is derived from a general consideration, and it is expected to have broad application. This presentation is based on the following papers:

Ikegawa, S., and T. Horinouchi (2016) Improved automatic estimation of winds at the cloud top of Venus using superposition of cross-correlation surfaces. Icarus, 271, 98-119.

Horinouchi, T., S. Murakami T. Kouyama, K. Ogohara, A. Yamazaki, M. Yamada, and S. Watanabe, Image velocimetry for clouds with relaxation labeling based on deformation consistency. Measurement Science and Technology, submitted.

Keywords: Cloud tracking, Atmosphere, Venus, PIV

Development of software WAN accelerator based on HpFP

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For LFNs (Long-Fat Networks) with 10 Gbps or more and satellite networks with large latency, a variety of TCP-based protocols have been proposed which show high performance on large latency network conditions. However, such TCP protocols are essentially unable to archive large bandwidth on high latency networks accompanied with packet-losses that are inevitable on practical LFNs or satellite networks. To overcome this issue, we designed a new data transfer protocol on TCP/IP transport layer built on top of UDP: High-performance and Flexible Protocol (HpFP). It constantly monitors latency (RTT) and packet losses, and conducts rate control and retransmission control based on them to enable higher bandwidth data transfer than 10 Gbps even on packet-loss conditions over LFNs. The basic concepts are addressed and protocol design of the HpFP are discussed. An applications to tansfer many data files in small size (e.g., 1MB x 10000 files) with almost wire-rate bandwidth (10 Gbps) is also addressed.
In this study we develop a software WAN accelerator based on the HpFP techniques. The objective of development of this protocol is for practical uses on a variety of networks, paying attention to the fairness with other traffices. In the near future, big data transfer with high speed is expected on LFNs such as SINET5.
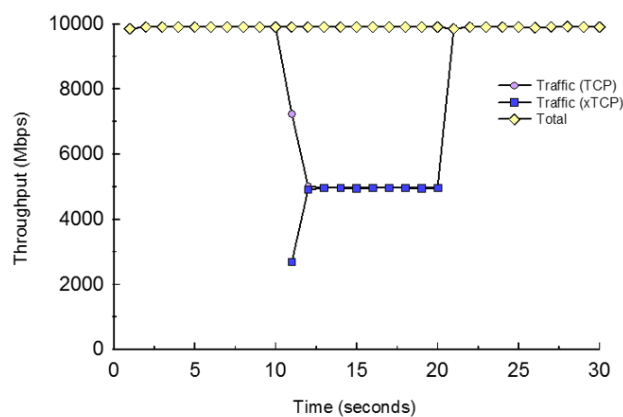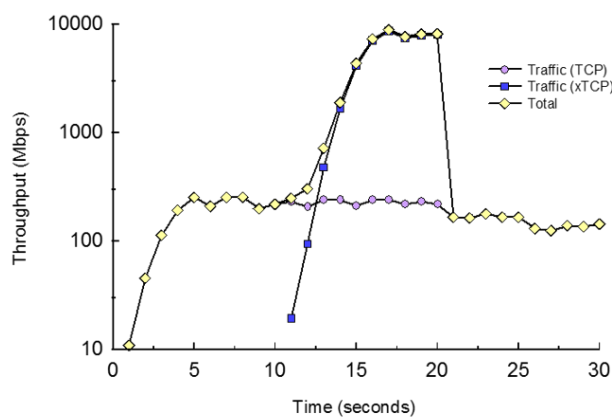
WAN accelerator throughputs with TCP (CUBIC) on the LFN (long fat network) with packet loss (left) and without packet loss (right)

Development of Remote Monitoring Camera with HD Resolution Working on Raspberry PI

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In this study, we introduce a new video streaming tool working on Raspberry Pi (RP). The RP is a series of small single-board computers developed in the United Kingdom by the RP Foundation to promote the teaching of basic computer science in schools and in developing countries. The original model became far more popular than anticipated, selling outside of its target market for uses such as robotics. According to the RP Foundation, over 5 million RPs have been sold before February 2015, making it the best-selling British computer.

The RP is recently arrestive in terms of the IoT (Internet of Things) devices with low cost and programable environment on a Debian-based operating system (OS), Raspbian. For global, regional and local observations of the Earth, light-weight sensors are preferable. No external power let (using solar power device), low cost network like MVNO (but low and unstable bandwidth), small power consumption, low cost in price and other factors are required for the IoT sensor devices.

We implement an original video streaming tool workins on the RP using its own H.264 hardware encode modeule onboard. We include our techniques in the HpFP, a data transfer protocol developed by CLEALINC technology and NICT (National Institute of Information and Communication Techology), such as Path MTU search, pace control, etc. There are wide variety of applications of the RP video streaming system; real-time drone operation, remote water level indicator, volcano monitoring, remote seismograph, thermometer. We demonstrate the low cost but high specification video streaming in the talk.
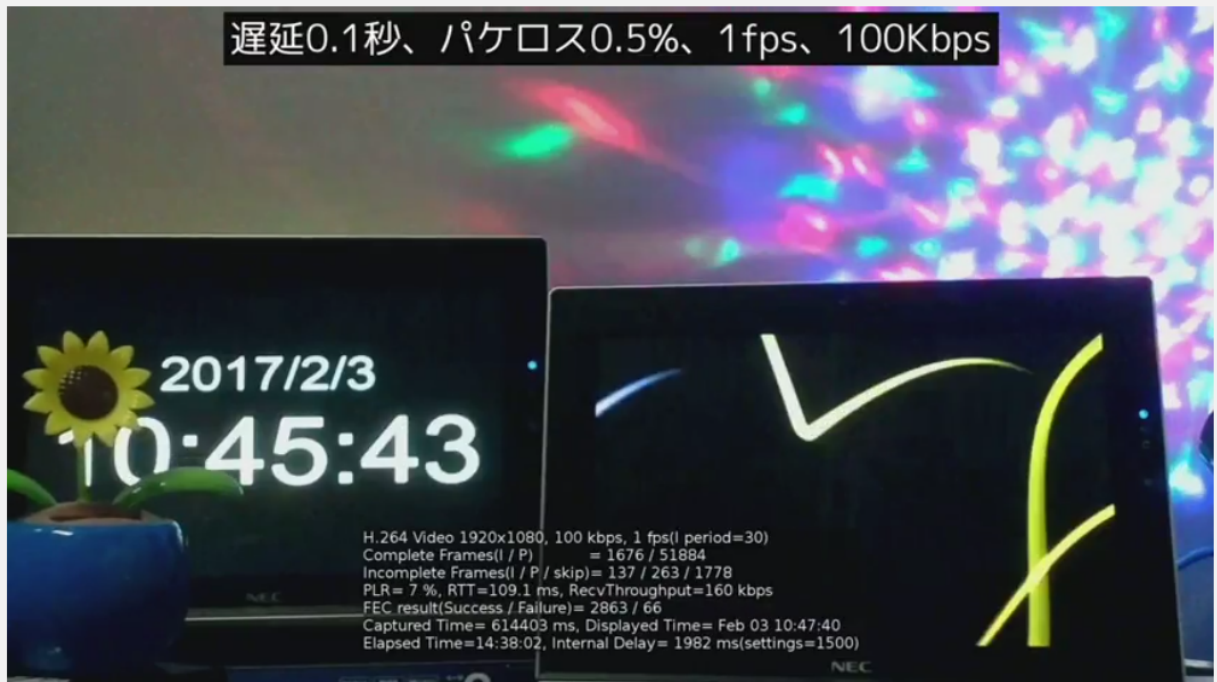
Open Science and Research Data Sharing

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Open Science is increasingly an important focus, in terms of not only scientific paper publication, but also it should be more stressed in terms of research data management, as another mode of modern scholarly communications as well as scholarship and research themselves in this digital era. Open Data and Open Science are increasingly becoming hot topics, in parallel to establishing ICSU-WDS (2008), G8 Open Data Charter (2013), deployment of RDA (2013), and so forth, in addition to development of Open Access of journal articles. National guiding principle of open science has been released by the Cabinet Office (March 2015). In this digital era, if Open Science practices become daily reality, e-infrastructure or common digital environment will be necessary platform for many research activities. Contribution from the Earth and Planetary Science community including JpGU and AGU is strongly expected to facilitate new challenges of science based this data management and infrastructure.

Keywords: Open Science, data sharing

Towards enhancement of detection accuracy of geothermal reservoir by a combination of remote sensing analysis and field survey data

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Development of more accurate geothermal-resource exploration is necessary for enhancement of geothermal energy use which is limited because of high exploration cost at present. One of the effective solutions is to improve the regional analysis by remote sensing using satellite imagery and topographic data. A fracture modeling through topographical analysis and an extraction of hydrothermal alteration zone using reflectance spectral data are efficient for the estimation of regional geothermal system. Besides, a combination of field survey result and regional analysis can provide more detailed information about a study area. Based on that background, this study is aimed to identify geothermal fluid paths by remote sensing analysis and field survey. Wayang Windu area located in West Java of Indonesia in which there is a geothermal power plant in operation was selected as a study site. As the remote sensing analysis, lineament mapping using a digital elevation model with *m spacing and estimation of alteration zones by ASTER image are implemented. Moreover, the radon survey was carried out in the study site. Radon survey is suitable to identify geothermal fluid paths because the radon concentration is sensitive the existence of fracture and the pressure and temperature condition of reservoir. Measurement wells with the 5 m depth at the maximum were prepared to measure correctly the radon concentration affected by the reservoir condition and this measurement has been repeated. We integrate these results obtained by different methods to increase the identification accuracy of fluid paths and deepen the geothermal system of the study site.
This research is supported by JST and JICA through Science and Technology Research Partnership for Sustainable Development (SATREPS).

Keywords: Geothermal resource exploration, Hydrothermal alteration, Remote sensing, Radon survey

IIIF-compliant multi-resolution access to spatio-temporal data and its application to Himawari-8 data

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Earth environmental data is large in space and time, and software for accessing data into arbitrary parts with arbitrary resolutions has been requested by many people. Various software systems that have been developed so far tried to fulfill those needs. Firstly, Google maps, and similar Web map services, proposed an access method called tiling that takes advantage of Web technologies. It standardized the unit of data access to a tile to enable the off-line rendering of huge number of tiles, the utilization of cache using fixed URIs, and succeeded in efficient data transmission by combining them with asynchronous access (called AJAX). These set of ideas are now standardized as Tile Map Service by Open Source Geospatial Foundation, and widely used as a standard spatial data service in the age of Web.

On the other hand, temporal data has not been standardized as spatial data. Several open source software libraries to visualize timeline are available, but none of them is regarded as the standard one. The author also worked on this issue in 2011 by developing software called SyncReel, which is used for multi-resolution access to temporal data such as weather chart data for 100 years, or AMeDAS data for 40 years. However, the variety of time series data makes it difficult to standardize the format to describe various events on the same timeline.

Our idea is to take advantage of an international protocol for accessing images called IIIF (International Image Interoperability Format), which was originally proposed for cultural heritage domains such as museums. We tried to apply this protocol to earth environmental data for multi-resolution access in space and time. IIIF is an international community whose activity has increased since around 2014. IIIF defines the JSON-LD format of information that data providers should offer, and a client that interprets the format can enjoy interoperability between different data providers and reduction of cost for implementing viewers. The most basic service is called IIIF Image API, which defines the standardized URI for accessing arbitrary parts of the image. This API does not depend on the type of images, so our idea is that this can be used as a basis for multi-resolution spatial access to earth environmental data.

We introduced this IIIF standard to a system for browsing visible images of Himawari-8 satellite. This system is composed of two sub-systems of a server and a client. The server system uses software called IIPImage, which is compatible with IIIF Image API. IIPImage was originally a high-performance image server developed for browsing high-resolution images in astronomy, but since version 1.0, it has functionality for IIIF. The client system uses software called Leaflet IIIF. Leaflet is a JavaScript library to work with tiled maps, so it matches well to IIIF which also uses tiled access, and it also offers advantage such as using libraries developed around Leaflet. These open source libraries enable us to develop a multi-resolution viewer with zoom-in/out functionality to access Himawari-8 visible images having the size of 11000 by 11000 pixels.

We developed this viewer more to release a new service called Himawari-8 Clipping. This is a service for clipping and a storing a rectangular region drawn on the viewer using a Leaflet-related library called Leaflet Draw. A clipped image is given a new URI with metadata, which may be useful for making the catalog of Himawari-8 images collecting meteorologically relevant scenes through collaborative work on

the Web.

In contrast to multi-resolution access in space, its extension in time is left for future work. The reason is the lack of time-series data in cultural heritage domains, where IIIF was originally developed. However, time-series data is prevalent in scientific domains such as earth environment, and the necessity for standardizing access to time series is significant. Extension into this direction is now under study, but the presentation will refer to recent progress on this issue.

Keywords: multi-resolution access, spatio-temporal data, IIIF, Himawari-8, standardization, image data
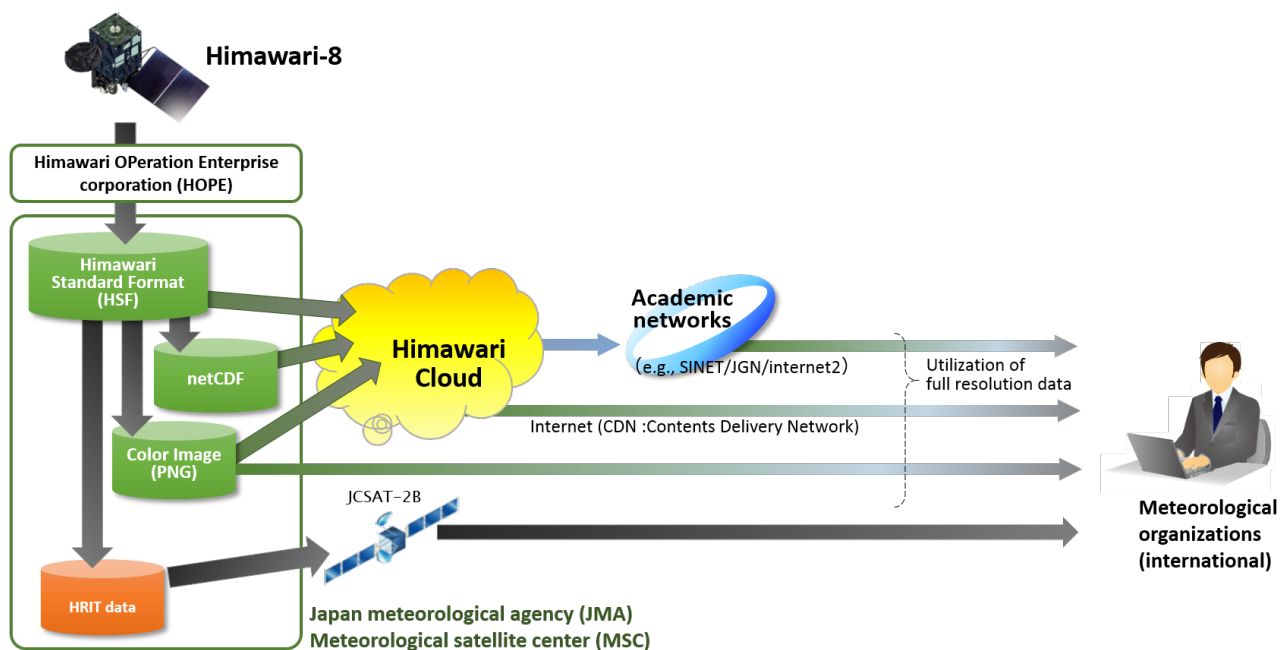
A web-based real-time and full-resolution data visualization for Himawari-8 satellite sensed images

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It has been almost four decades since the first launch of geostationary meteorological satellite by Japan Meteorological Agency (JMA). The specifications of of geostationary meteorological satellites have shown tremendous progresses along with the generations, which is now entering its third generation. The third-generation GMSs not only yield basic data for weather monitoring, but also globally observe the Earth's environment. The development of multi-channel imagers with improved spatial resolution onboard the third-generation of geostationary meteorological satellites brings us meteorological data in larger size than those of the second-generation ones. Thus, new techniques for domestic and world-wide dissemination of the observational big data are needed. In this paper, we develop a web-based data visualization for Himawari-8 satellite sensed images in real time and with full resolution. This data visualization is supported by the ecosystems, which uses a tiled pyramid representation for terrain on an academic cloud system. We evaluate the performance of our techniques for domestic and international users on laboratory experiments. The results show that our data visualization is suitable for practical use on a temporal preview of observation image data for the domestic users with high-speed networks. Moreover, in the paper, we discuss a protocol handler for web acceleration developed based on our new network protocol, HpFP (High-performance and Flexible Protocol) [1].
K. T. Murata, P. Pavarangkoon, K. Yamamoto, Y. Nagaya, T. Mizuhara, A. Takaki, K. Muranaga, E. Kimura, T. Ikeda, K. Ikeda, and J. Tanaka, "A quality measurement tool for high-speed data transfer in long fat networks," in Proc. 24th Int. Conf. Software, Telecommunications and Computer Networks (SoftCOM), 2016. doi: 10.1109/SOFTCOM.2016.7772111

Himawari-8

Himawari OPeration Enterprise corporation (HOPE)

Himawari Standard Format (HSF)

netCDF

Color Image (PNG)

HRIT data

Himawari Cloud

Academic networks

（e.g., SINET/JGN/internet2）

Internet (CDN :Contents Delivery Network)

JCSAT－2B

Utilization of full resolution data

Meteorological organizations (international)

Japan meteorological agency (JMA)
Meteorological satellite center (MSC)

Automatic extraction and tracking of hot spots from time-series three dimensional grid data - application to meteorological radar data -

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A large amount of time-series three dimensional data has been accumulated also in the field of Earth and planetary science. We have developied a method of automatic extraction and tracking of hot spot areas included in a time-series three dimensional data, aiming to discover spatio-temporal pattens from them. The distribution of hot spots is modeled by a mixture of multivariate normal distribution. Hot spots are then extracted by obtaining the model parameters via EM algorithm. We used position of the grid data where the observed value exceeds the threshold as input in previous study. We modified this method to use data values themselves as weight coefficients during EM algorithm. The method was applied to synthetic data and real data of phased array meteorological radar data and the accuracy of detected number of hot spots was siginificantly imporoved. We are aiming to apply this method to detection of localized heavy rainfall precursor from 3D meteorological radar data.

Keywords: data mining, knowledge discovery, mixture model, phased array meteorological radar

The Systems Design and Project Status of the HAKUTO Micro Lunar Rover for Exploration

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This paper describes the project status of HAKUTO rovers, its systems and the results of the field experiment. HAKUTO is the Japanese team participating in the Google Lunar XPRIZE. This team is consisted of a venture company, Tohoku university and pro bono members.
The Google Lunar XPRIZE is an unprecedented competition, challenging privately funded teams to accomplish three main goals: successfully land a spacecraft on the lunar surface, run the rover on the lunar surface at least 500 meters, and transmit high-definition video and image back to earth. HAKUTO has developed a small and lightweight dual rover system to fulfill the above Google Lunar XPRIZE requirement. Demonstration of rovers' performance in space environment is verified by conducting thermal vacuum testing, vibration testing, and field testing at Nakatajima sand dune. Currently, HAKUTO is preparing the Flight Model rovers which are supposed to be launched in 2017.

Keywords: Moon, Lunar Exploration, Rover, HpFP, UDP, TCP/IP
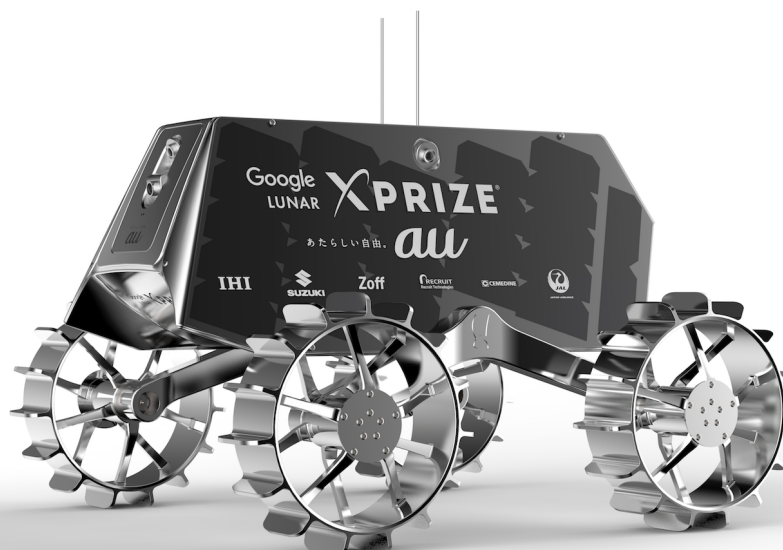
An experiment of high-speed data transfer technique from Syowa via INTELSAT

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Achieving the quality of service (QoS) is an important requirement in a communication network. Satellite communication is posing many challenges due to the limitation of transmission control protocol (TCP) over networks with high latency. To overcome these issues, the wide area network (WAN) optimization provides the data transfer on such long-distance networks. However, this optimization is not able to utilize the available bandwidth of provided network efficiently since it performs fixed bandwidth allocation. This paper proposes a technique to enhance the available bandwidth utilization for International Telecommunications Satellite Organization (ITSO, or INTELSAT) network. This technique adopts a high-speed data transfer protocol, named high-performance and flexible protocol (HpFP), to transfer data between the satellite and the ground station. The HpFP is a connection-oriented protocol to work on the top of user datagram protocol (UDP) and provides us with a stream-type of reliable data transfer even under high packet loss rate. One of the ingenious attempts in the HpFP is to set an internal target throughput for pace control of sending packets. Since this parameter setting is time-dependent, the target throughput is calculated based on network conditions monitored by the HpFP. The HpFP detects the unused bandwidth in the satellite bandwidth resources at every moment, then dynamically allocates HpFP data transfers. The results of laboratory experiments show how effectively the HpFP utilizes the available network bandwidth in the condition of the WAN optimization control on INTELSAT satellite network.

[1] Praphan Pavarangkoon, K. T. Murata, M. Okada, K. Yamamoto, Y. Nagaya, T. Mizuhara, A. Takaki, K. Muranaga, and E. Kimura, "Bandwidth utilization enhancement using high-performance and flexible protocol for INTELSAT satellite network," in Proc. 7th IEEE Annu. Information Technology, Electronics and Mobile Communication Conf. (IEMCON), 2016. doi: 10.1109/IEMCON.2016.7746292
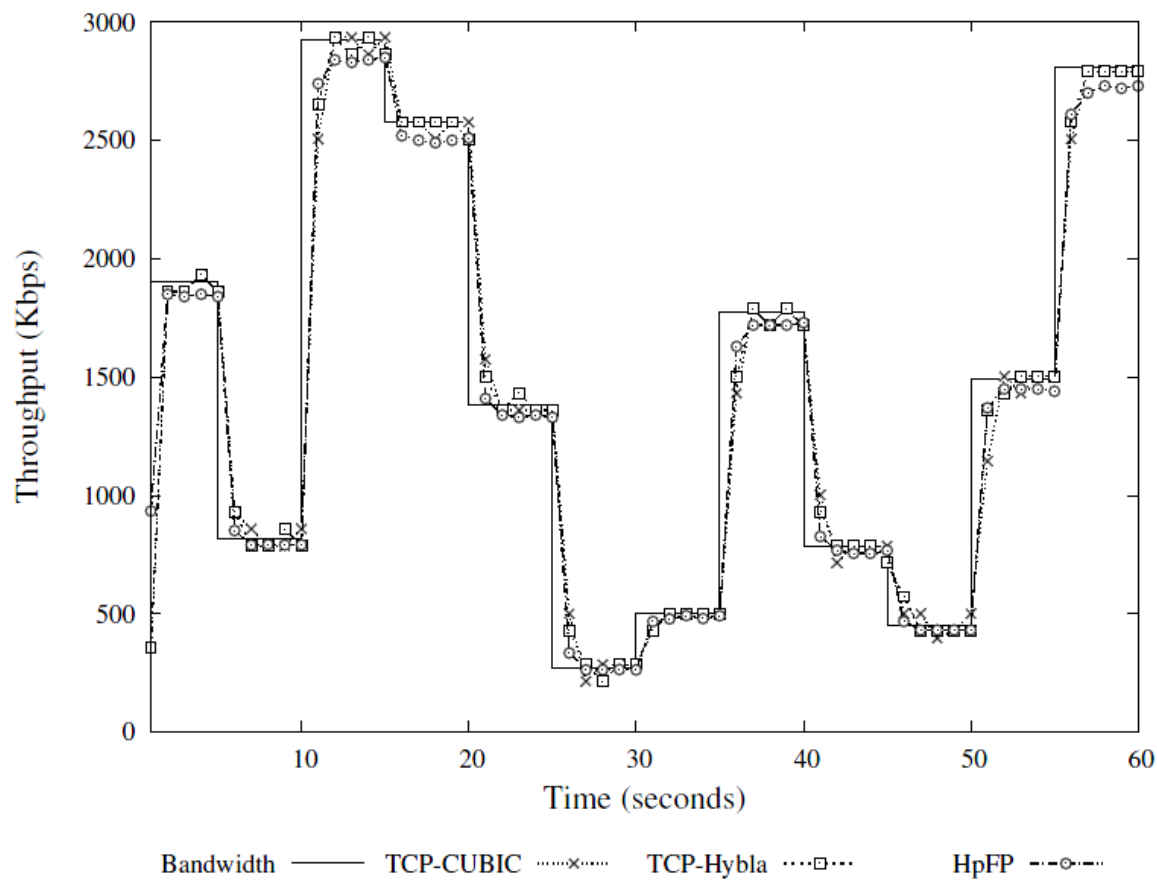
Fig. 10. Comparison of TCP-CUBIC, TCP-Hybla, and HpFP under the situation with the changing interval of the available bandwidths in every 5 sec

An experiment of high-bandwidth virtual remote storage (HbVRS) system on long fat network (LFN)

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Science cloud is a cloud system specialized for data intensive/centric science, which is based on a concept of the fourth paradigm proposed by Jim Gray in 2009. However, only a few science cloud systems have ever yielded tremendous scientific results so far. High-bandwidth storage I/O is one of the important issues to be overcome for big data sciences. In the study, we propose a high-bandwidth virtual remote storage (HbVRS) tool using a distributed file system (Gfarm) and a UDP-based data transfer protocol (HpFP) [1]. The tool is based on our examination of parallel HpFP data transfer in 10 Gbps using a long-distance 10G network (long fat network: LFN) between Japan and USA crossing the Pacific. We installed an application to draw a set of time sequential graphic files using the tool on the NICT Science Cloud. We successfully read data files in order of time sequence from a virtual storage as fast as more than 20 Gbps. The present results suggest that client hosts connected with a long fat network will be able to access to big data stored in cloud storage wherever over the world it is located. An application is demonstrated using the HbVRS [1].

[1] Ken T. Murata, P. Pavarangkoon, K. Yamamoto, , Y. Nagaya, K. Muranaga, T. Mizuhara, A. Takaki, O. Tatebe, and E. Kimura, "Multiple streams of UDT and HpFP protocols for high-bandwidth remote storage system in long fat network," in Proc. 7th IEEE Annu. Information Technology, Electronics and Mobile Communication Conf. (IEMCON), 2016. doi: 10.1109/IEMCON.2016.7746276
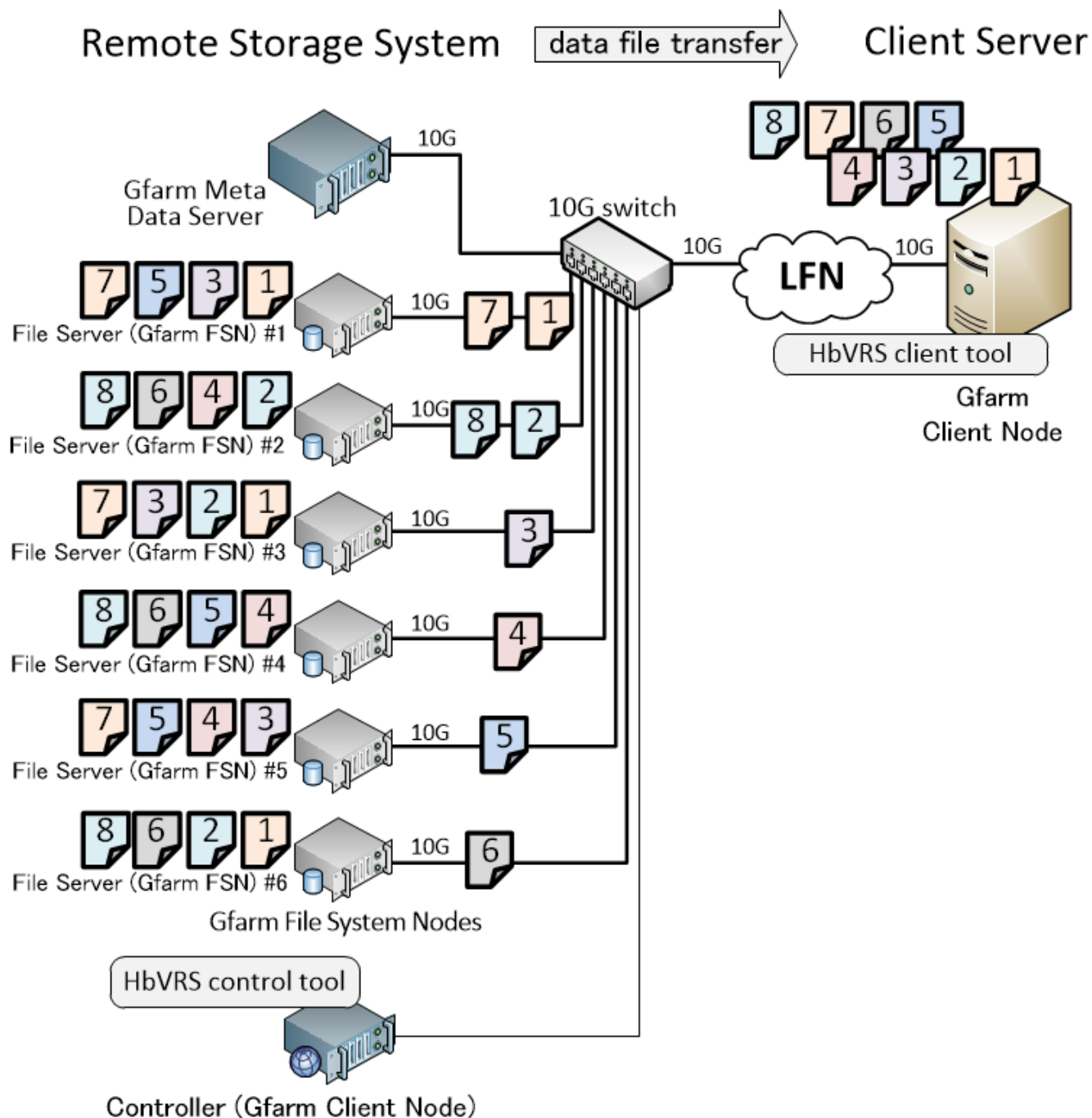
Real-time 3D Visualization of Weather Radar Data in Full Resolution via Concurrent Processing and High-speed Transfer in Science Cloud

Kentaro Ukawa[1], *Kazuya Muranaga[1], Praphan Pavarangkoon[2], Kazunori Yamamoto[2], Ken T. Murata[2], Eizen Kimura[3]

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With the tremendous development of remote sensing technologies, a large amount of observation data are generated from sensors. Since each sensor generates data periodically, e.g., every minute, a concurrent data processing using a cloud system plays an important role in the modern design process. This paper focuses on concurrent data processing techniques for an X-band phased array weather radar (PAWR) using high-speed network, parallel data processing system, and large-scale storage system. The PAWR at National Institute of Information and Communications Technology (NICT), Japan rotates in 30 sec to capture a 3D structure of rainfalls within 60 km in radius and 15 km in altitude. In this paper, we develop a real-time 3D visualization system of the observation data of the PAWR. Our visualization is carried out from 54 sec to 69 sec (depending on the weather conditions) after every observation period, which is in the same time scale with other conventional 2D visualization of X-band weather radars. In addition, we discuss a combination of cloud ecosystems for the concurrent processing at low cost. The methodology is considered as a pioneering case study to develop of a variety of real-time data processing systems of big data via remote sensing [1].

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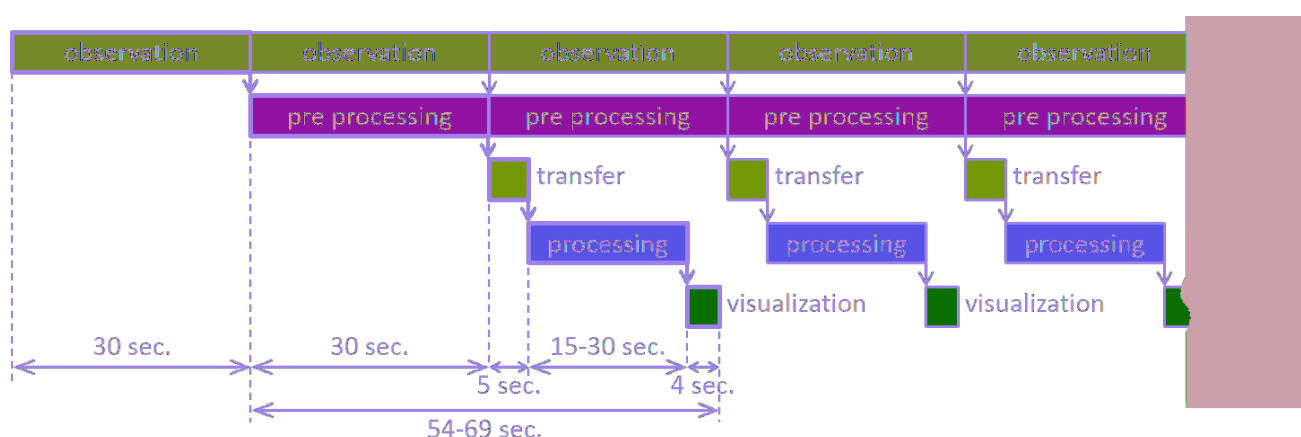
# An examination of high-speed data transfer on high throughput satellites using novel network protocol

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For network communications using modern high throughput satellite (HTS) on geostationary orbits, network throughput of transmission control protocol (TCP), one of the most popular protocols, is limited due to the packet loss on the satellite link. The packet loss is mainly caused by the attenuation of signals in severe weather conditions like heavy rain. It is high time to develop novel network communication techniques on the transport layer in TCP/IP designed for the systems and applications in broadband communications. In this paper, we introduce a high-speed data transfer protocol, named high-performance and flexible protocol (HpFP) [1], to achieve high throughput for the HTS even with packet loss. The HpFP, in comparison with TCP-Hybla and UDP-based data transfer (UDT) protocols, is evaluated on a laboratory experiment simulating a geostationary orbit satellite link of 10 Gbps. It is clarified that the HpFP outperforms both the TCP-Hybla and the UDT showing high throughputs (close to 10 Gbps) when the packet loss ratio (PLR) is 1%, and remains more than 1 Gbps under even 10% PLR condition. Moreover, in case of no packet loss, the HpFP exhibits a quick start-up time (6 sec) at the initial phase to achieve 10 Gbps, while the TCP-Hybla and the UDT take 9 sec and 16 sec to their maximum throughputs, respectively [2].

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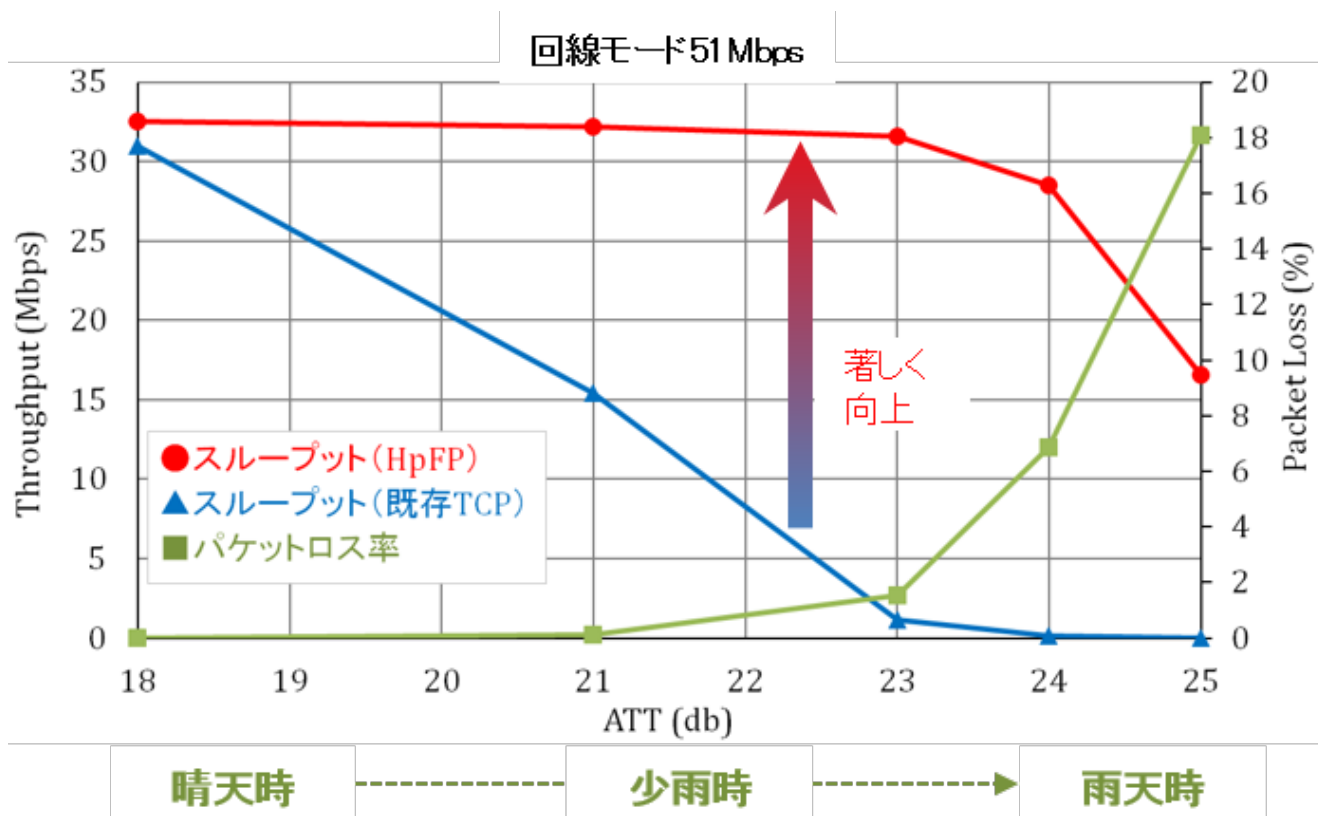
Cyber Earth: A new technical concept for global investigations of Earth

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In the present paper, the author proposed a concept of the Cyber Earth as a basic approach for the global understanding of the Earth system. In order for our global understandings from a variety of observation and simulation data of Earth sciences, we need a methodology to analyze huge size of big science data. The Cyber Earth is a concept to declare that, for our global understandings, mash-up of information and communication technologies for big data plays an important role. This concept is based on several technological ideas, such as data centric/intensive science, the fourth paradigm, science cloud, big-data science. All of the data, observation data and simulation data, are once transferred and stored on a science cloud system. Data preservation and data stewardship is important since most of the data is so precious that they are never observed again at the observed time and location. Big data processing, including visualization, is also important. The data processing must be applicable for any types of digital data from either Earth observation or simulation. Integrated data processing technology for such variety of data type is preferable.

The Cyber Earth is composed of three methodologies; the Network Earth, the Digital Earth and the Virtual Earth. The Network Earth is a concept that role of network is important for data transfer and collection to the cloud. For global monitoring we often build up global observatories on the Earth. Integrated operations and easy management of the remote sites are significant for labor-saving. The Digital Earth is a concept that long-term data preservation is one of the most expected functions to a science cloud. Data files must be saved and managed under DR (disaster recovery) environment. Easy data publication should be functionally synchronized with data preservation. The Virtual Earth is a concept that every digital data must be processed or visualized to be shown on the same framework with other data. Inter-disciplinary data preview, in space and/or in time, makes our global and functional understanding of the Earth system. Immersive visualization may work effectively to understand or discover any interactions between data.

Three-dimensional Visualization and Web Sharing of Geological Logs using FOSS4G

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Recently, Web sharing of subsurface geospatial information has received increasing attention because of its importance in disaster mitigation / prevention. The purpose of this study is to establish technology to share two- and three-dimensional (2D / 3D) geological information on the Web using Free and Open Source Software for Geoinformatics / Geospatial (FOSS4G). As a first step of our work, we constructed a database of geological logs using PostgreSQL and developed a web mapping system for fundamental geological information, such as geological map and geological logs, using Leaflet JavaScript library. Linking the database and the mapping system enables to visualize geological logs within a specified region in 2D / 3D. This study was supported by JSPS KAKENHI Grant Number JP16K21677.

The study of visualization of dense and large area DEM data with Red Relief Image Map

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1.Introduction

Advancement of aviation laser measurement technology has made it possible to obtain accurate DEM data excluding the influence of trees in a short time. Up to now, laser measurement has been done in the range of 50% of country. On the other hand, because the data is high precise, it was also a big challenge for conventional terrain representation techniques to express an appropriate scale for easy to use in field surveys. The RRIM was developed in 2002 as a method to visualize very complicated and precise topography data by laser measurement (Chiba et al., 2006, etc.). In this study, we report on the principle of the RRIM and recent achievements on application to big data which not from laser measurement.

2.Red Relief Image Map (RRIM)

There are several methods for creating images directly from DEM by calculation, such as shadow plots, oblique maps, and advanced step diagrams, but each has its advantages and disadvantages. The common problem of these methods is difficult to express by one sheet and the 3-dimensional expression will be changed with rotation. The RRIM had been developed as a method for solve these problems. For create RRIM, after obtain the inclination, negative openness and positive openness from DEM, we multiplied the image of inclination which is proportional to the red saturation and the image of ridge valley value which obtained from the positive openness and the negative openness and are proportional to the lightness. Since this image is perceived as ortho, it is expressed stereoscopically, so it was possible to incorporate much information into a small scale figure. The one used for the visualization of the laser measurement data was very effective for the field survey in the jungle area. The beginning of the development of RRIM was the Aokigahara area in Mt. Fuji, but since then it has been used not only for volcanoes in various places but also for landslide surveys and active fault surveys.

3.Expansion of scope of application

We applied it to data with larger mesh size, which proved that it is possible to express the wider terrain clearly. It has been evaluated to be useful for topography understanding by applying to 10 m mesh data in Japan and 4 km mesh data of the whole Earth so far. In addition, this expression technique can be applied as long as it is data having one Z value for a set of YX values. Therefore, we tried to apply relief data of 0.1 micron mesh by laser microscope and data of Mars and Moon. In this poster, we will introduce contrivances of expressions that are tailored to the purpose of each data with respect to attempts to express data other than those.

4.Retardation color palette

The RRIM has a problem that it can't get altitude information and tilt direction information. For that confrontation, it has been done to overlay contour diagrams or to overlay weak shadows, but it was difficult to understand. Recently, I attempted to approach this problem by using interference fringe color by using retardation color palette from DEM. I will introduce the current idea here.

Keywords: Red Relief Image Map, DEM, visualization

Development of database system for cruise information of JAMSTEC vessels and statistical analysis of observation downtime

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Japan Agency for Maine-Earth Science and Technology (JAMSTEC) has seven research vessels and controls the research cruise of these vessels. Each year, several tens of research cruises are carried out, and a large amount of marine observation data is acquired. JAMSTEC has not only the observation data but also a large amount of navigation data of past cruises. There were cruises in which many of the scheduled observations could not be implemented due to various causes. For example, in some research cruises carried out in the fall in the surrounding sea of the Japanese Islands, many of observations were canceled by typhoon. Scheduled observations cannot be performed and sufficient observation results cannot be obtained so that progress of the research will be prevented. However, even though there are navigation data, it has not been examined how many observations were canceled in past cruises and what caused the observation downtime. At present, JAMSTEC has to schedule all research cruises for the next fiscal year one year before, which may prevent efficient operation of the research cruise. In this study, we are developing database system for the cruise information operated in the past several tens years to clarify observation downtime for each cruise and what caused the downtime. We are also analyzing statistically the downtime data to describe the relationship between the downtime and various factors of the cruise such as season, sea area, observation equipment, vessel, etc. The analysis results will provide useful information to plan the cruise. Furthermore we will analyze all information of past cruises by machine learning, and we will predict the downtime of the planned cruise and propose better research cruise plan, which will help to obtain the sufficient observation results and to advance the research. Acknowledgments: we are grateful to Mr. Morisaki and Ms. Sada for their supports.

Three dimensional Geological Modeling Using Geological Information of Vietnam

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In Southeast Asian area, the environmental problems such as land subsidence, flooding occurs by heavy rain, traffic problem and groundwater pollution have been increasing in recent years. This main reason is rapid urbanization and population increase. Regarding the mitigation and prevention of the environmental issues of urban area, it is important to prepare and analyze with the geological information. For the solution of these issues, it is necessary to provide the geological information accurately and effectively. The 3D (three-dimensional) geological model is an important geological information generated as a result of geological analysis based on the fundamental field survey data and the knowledge of the geologist. The method of 3D geological modeling based on the logical model of geological structure has been developed by Masumoto et al. (1997) and Shiono et al. (1998), and its actual visualization 3D geological modeling has been proposed by Masumoto et al. (2004) using GRASS GIS and Yonezawa et al. (2004) using Visual Basic program Geomodel2000.

In this study, we generate the DEM using the elevation data. DEM is a digital representation of ground surface topography and the most important element of topographic analysis. And, we analyzed the borehole data for the well construction of Hanoi city. Finally, we constructed the 3D geological model of Hanoi city and visualized it using GRASS GIS.

Research area is the center part of Hanoi city, the capital of Vietnam, the environmental problems have been increasing in recent years. The main reason is rapid urbanization and water control. The urbanization of Hanoi city has a relationship with the geological urban transformation as a landfill historically.

The 3D geological model is composed the DEMs of the geological boundary surfaces and the logical model. The spatial distribution and the relation of geological units are expressed in the logical model based on the fundamental field data and the knowledge. Thus the logical model of geological structure and the boundary surface are calculated for the visualization of 3D geological model. The outline of constructing of 3D geological model is as follows.

We can verify the logical consistency from the stratigraphic correlation and generate the geological event using the classify and arrange module (Shiono et al., 1998; Iwamura et al. 2008). It is calculated from the recursive definition proposed in Yonezawa et al. (2005). The logical model of geological structure is constructed by this event using the logical modeling module. Each geological boundary surface DEM is estimated using BS-Horizon method by Nonogaki et al. (2008). In geological function module, 3D geological model is constructed virtually using the logical model and DEMs. In this study, the data of logical model and each DEM of geological boundary are outputted from GRASS GIS of FOSS4G, the 3D geological model can be expressed using the visualization tool NVIZ of GRASS GIS.

The 3D geological model is provided as 2D and 3D visualization. We displayed a geological cross section of the 3D geological model. Future work is needed to identify the actual geological structure of Hanoi city to compare the 3D geological model.

Keywords: DEM, Borehole Data, Logical Model of Geological Structure, 3D geological model, Vietnam