PORTFOLIO

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山辺真幸

Nov. 3, 2021

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2020 -

Time-space-based 3D visualization of SARS-CoV-2 phylogeny

https://timespacephylogeny.xyz/



In a global outbreak such as COVID-19, visualization is essential since that promotes scientific understanding based on the available data, even if the general population lacks expert knowledge.

We proposed a method to associate phylogenies with time and space and combine them into a single three-dimensional graph.

The world map is placed perpendicular to the time axis. Cubes represent variants. To avoid a complete overlap, we put the cubes slightly shifted from the country's representative point where the mutation was collected.

If we merely extend traditional two-dimensional phylogenetic algorithms to 3D, we would obtain a visual clutter. We simplified the edges and applied edge bundling to curve the edges, using a spline model to improve this aspect.

The graph displays when and where variant strains of the virus have been discovered using the viral sequence and sampling information of SARS-CoV-2 stored in the GISAID. By filling in a map as time passes, the transmission route of the virus becomes visible. Due to the ability to view complex, detailed phenomena with a wide field of vision, this tool is anticipated to help guide specialists in debate and make new discoveries.



Poster Presentation at the conference in bioinformatics – Visualizing Biological Data 2021 (Mar. 24, 2021)

https://vizbi.org/Posters/2021/vB06

Time-space-based visualization of SARS-CoV-2 phylogeny

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1 Abstract

This study aimed to present a method to visualize a phylogenetic tree, associated with time and space, in three dimensions

We applied this method to visualize the phylogeny of SARS-CoV-2 causing COVID-19 to understand their temporal and geographic spread. We subsequently generated a video to understand the spread of SARS-CoV-2 based on our system. According to the questionnaire survey, over 90% of the audience, with no specialized knowledge, found the video easy-to-understand.

2 Motivation

In a global outbreak such as COVID-19, visualization is extremely important, since that promotes scientific understanding based on the available data, even if the general population lacks expert knowledge.

Some tools help in visualizing phylogenetic relationships of viruses based on their mutation patterns [1,2,3,4]. However, merely associating phylogenies with time cannot enable full understanding of the geographical spread. Maps and phylogenies are usually represented on separate diagrams, which makes it difficult to understand. Therefore, we proposed a method to associate phylogenies with both time and space, and combine them into a single three-dimensional graph.

3 Materials & Methods

Dataset

We used the global subsampling of nextregions provided by Nextstrain [6] based on the viral sequence and sampling information data stored in the GISAID [7]. In this study, we visualized the data released on February 2, 2021.

Projection

Figure 1 illustrates the method of projection to 3D. The map is placed perpendicular to the time axis. Cubes represent variants. To avoid a complete overlap, we placed the cubes at a slight shift from the country's representative point from where the mutation was collected.



Three-dimensional coordinate system. Users can move the map in paral-lel along the time axis.

Improvement of Visualization

If we merely extend Sagulenko et al.'s TimeTree algorithm [8] to 3D, we would obtain a visual clutter. To improve this aspect, we simplified the edges and applied edge bundling [9] to curve the edges using a spline model.



Figure 2: (a) To simplify the shape of edges in the group having the same divergence (Dn) in the same branch, we shifted the position of branches to that of earliest collected mutation (C2). The result is shown in (b). Thereafter, we bundled the edges with a non-weighted Bezier Curve; the esult is shown in (c)

References and Acknowledgements

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- [8] Sagulenko P, Puller V, Neher RA (2018). TreeTime: Maximum-likelihood phylodynamic analysis. Virus Evol, 4(1), vex042. DOI 10.1039/we/wold2. [9] Hoften D (2006), Hierarchical Edge Bundles: Visualization of Adjacency Relations in Hierarchical Data. IEEE Transactions on Vi Computer Engines, 12(5), 741-748. DOI: 10.1109/TVGC2006.147.
- ork was partially supported by NHK Educational Corporation and we acknowledge the help of Kentaro Oku in technical



4 Results

Variations of Color Mapping





Figure 3: (Top) Color indicates the divergence of genomes com-bared to that of the genome reference Wuhan-Hu-1/2019. (Bottom) fhe color codes indicate three different lineages of N501Y variants.

Comparison of 3D and 2D Representations



Figure 5: The color codes indicate the six geographical regions. The top image was generated by our method, whereas the bottom one was generated by Nextstrain.

5 Visual Case Studies to Understand The Spread of SARS-CoV-2

We applied our method to generate a graph or create animation to understand the spread of SARS-CoV-2.

Filtering

(Left) Figure 6: D614G was first observed in late January 2020. Thereafter, it spread rapidly, mainly across Europe, accounting for 60% of all global samples by early March; by June 2020, almost all ored the D614G variants. strains har

(Top) Figure 7: Figure 5 viewed from a different angle; the image shows how travel and border-crossing restrictions, imposed by vari ous countries from mid-March 2020, suppressed the spread across

6 Evaluation

We summarized Figure 3 (top) and Figure 8 into a Table 1: Age of participants 3-minute video and conducted a seminar regarding the spread of SARS-CoV-2 at a science museum. We, thereafter, conducted a questionnaire survey for the viewers, who had no technical knowledge (Table 1). Their impressions about the video are shown in Table 2.

| Age (years) | Number | Qu |
|-------------|--------|----|
| 0 - 19 | 3 | It |
| 20 - 29 | 1 | lt |
| 30 - 39 | 6 | It |
| 40 - 49 | 2 | lt |
| 50 - 59 | 1 | It |
| 60 - | 3 | |

Table 2: Results of the questionnaire survey (n = 16)

| Questions | Agree | Undecided | Disagree |
|--|------------|-----------|-----------|
| It was easy to understand. | 15 (93.8%) | 1 (6.2%) | 0 |
| It was beautiful. | 13 (81.3%) | 2 (12.5%) | 1 (6.2%) |
| It drew my attention and curiosity. | 15 (93.8%) | 0 | 1 (6.2%) |
| It gave me new knowledge about SARS-CoV-2. | 16 (100%) | 0 | 0 |
| It clarified my understanding of SARS-CoV-2. | 14 (87.5%) | 0 | 2 (12.5%) |
| | | | |

Worldwide Movement Restrictions

Exhibition

Resonant Media – Possibilities of 8K Visualization Shibuya, Tokyo, Japan (Mar. 14–31, 2021)

The 8K version of this work was invited to an exhibition. The exhibition, titled "Resonant Media – Possibilities of 8K Visualization" took place in Shibuya, Tokyo, from March 14 to March 31, 2021, as part of the "8K Future Projects" collaboration between Japan's largest public broadcaster NHK and Ars Electronica Futurelab. Website: https://ars.electronica.art/futurelab/de/projects-resonant-media-possibilities-of-8k-visualization/

Science workshop

The National Museum of Emerging Science and Innovation of Japan (Dec. 5-6, 2020)

We made a short video for a public workshop to learn about COVID-19 at the National Museum of Emerging Science and Innovation of Japan (MIRAIKAN). According to the questionnaire survey, over 90% of the audience found the video easy to understand with no specialized knowledge. (n=16)

TV Programs

NHK Today's Close-Up (July 9, 2021)

"Halting Virus Variants: Infection Paths and Preventive Strategies" https://www3.nhk.or.jp/nhkworld/en/tv/closeup/20210709/4002832/

■ 4K/8K Ultra-high-definition broadcasting

NHK BS8K (Oct. 17, 2020) NHK BS4K (Sept. 26, 2020)

"Time-space-based 3D visualization of SARS-CoV-2 phylogeny" Credit: Masaki YAMABE, Lead, visualization design and development So NAKAGAWA, Scientific advisor Akira WAKITA, Supervisor Kentaro OKU, Technical support NHK Educational Corp., Scientific research support

COVID-19: Space-time visualization of infection risk in Japan

This three-dimensional graph shows the risk of infection based on the location information of COVID-19 cases reported in Japan between March 2020 and December 2020.

The about 12,000 dots on a map indicate the locations of cases. The height from the ground surface indicates the date of the reported cases. For example, a height of 0 meters corresponds to December 31, and each rise of about 500 meters indicates one day earlier.

The objects, such as a bubble, above many cities visualize the density of infection risk. The colors of the objects indicate the risk level:

Red: Five or more cases occurred per day within a four-square-kilometer area.

Yellow: One or more cases occurred per day within a four-square-kilometer area.

Blue: One or more cases occurred per four days within a four-square-kilometer area.

In the early days, the highest risk appeared in crowded areas of the city center. Then the highest risk decreased over time, and slightly higher risks spread to the suburbs through the transportation network.

March to May (first period)

October to December (third period)

The graphs on the left show the distribution of the risks in Tokyo.

We visualized three different patterns: March to May (first period), June to September (second period), and October to December (third period). The inside of the white line shows the areas where many people move as derived from the analysis of cell phone signals. Transportation networks connect these areas.

The "center of infection" appeared to be concentrated in the city center in the first period. In contrast, it tended to disperse to the downtown suburbs through the transportation network in the second and third periods.

We provided these visualizations for broadcasting to Japanese news programs featuring COVID-19 in Japan.

(Dr. Tomoki NAKAYA kindly provided his program to analyze the time-space-based density.)

PROJECTS

TV Programs

NHK Documentary (Dec. 13, 2020) NHK Today's Close-Up (Jan. 13, 2021)

4K/8K Ultra-high-definition broadcasting

NHK BS8K (Oct. 17, 2020) NHK BS4K (Sept. 26, 2020)

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"COVID-19: Space-time visualization of infection risk in Japan" Credit:

Masaki YAMABE, Lead, visualization design and development Tomoki NAKAYA, Scientific advisor and technical support Kentaro OKU, Technical support NHK Educational Corp., Scientific research support Visualization of the population projection for Japan

I created this work for an exhibition sponsored by the Ministry of Health, Labour and Welfare to explain the situation of nursing care and the declining birthrate in Japan.

The "population pyramid" is well-known as a simple way to show the population structure by age group. However, while it shows the composition of the population at a certain point in time, it does not show the long-term changes in population composition.

Pedro Cruz et al. proposed a method to visualize the process of demographic change due to immigration in the U.S. on a single graph that resembles the annual rings of a distorted tree, using society as a tree and the population as the tree's cells [1]. I developed a program based on the method proposed by Cruz et al. to visualize the population composition by age, not by immigration. I intended to provide more awareness of how a sustainable society should grow through an organic visualization rather than a simple, geometric pyramidal graph.

[1] Pedro Cruz, Simulated Dendrochronology of U.S. Immigration, https://web.northeastern.edu/naturalizingimmigration-dataviz/

PROJECTS

Credit: Masaki YAMABE, Visualization design and development

Exhibition

"Oi Oi Oiten" (Mar. 21 – 25, 2019) at Arts Chiyoda 3331, Tokyo

These posters and the 4K video visualize the period from 2040 to 2064, based on population projection data from the National Institute of Population and Social Security Research.

The Exhibition's Website https://korekara-pj.net/oioioiten/

Visualizing the dynamics of international trade

I am developing a visualization tool for visual analysis in environmental economics, collaborating with Dr. Keiichiro KANEMOTO, an Associate Professor at the Research Institute for Humanity and Nature.

It allows a user to explore the related interdependencies between importing and exporting countries and regions.

The graph above and on the left indicate bilateral trade in natural resources between more than 200 countries and territories.

"Visualizing the dynamics of international trade" Credit:

Masaki YAMABE, Lead, visualization design and development Keiichiro KANEMOTO, Scientific advisor

Visualization of the movement of ships over the centuries

Comparative visualization of marine transport in the 18th and the 21st centuries

2017 - 2019

This visualization aims to help a viewer intuitively and casually understand the shift to a modern economy and technological innovations in marine transport.

We visualized the movement of ships over two eras, separated by about 200 years—comprising one database named CLIWOC from the digitized 18th-century logbooks and one based on a ship's tracking service, "VesselFinder," in 2017. The differences between the visualizations raise a viewer's curiosity and motivation to understand historical changes. For example, the difference in trajectory patterns—twisting or strait—or the ship's speed helps a viewer understand the change in the mode of propulsion from sails to an engine over the two chronicled periods.

In collaboration with Tadashi NAGASHIMA. Special thanks to Tomoko SHIROYAMA.

Vessel's trajectories from 1750 to 1850.

Vessel's trajectories in January 2017

"Art Photo Tokyo" Shibuya, Tokyo (Nov. 16 – Dec. 2, 2018)

In this exhibition, we emphasized the differences using two side by side displays. The juxtaposition of the visualizations made a viewer feel the overcrowding and excesses of modern society, such as the expansion of the global economy and dependence on fossil fuels through the differences observed in the wake, canals traversed, and speed.

"Visualization of the movement of ships over the centuries" Credit:

Masaki YAMABE, Lead and development Tadashi NAGASHIMA, Collaborative development Tomoko SHIROYAMA, Scientific dvisor Akira WAKITA, Supervisor Takahiro TSUSHIMA, Photos

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PROJECTS

2017 - 2018

Visualization of air conditioner

Joint Research - Technology Innovation Center, Daikin Industries, Ltd. and Keio University SFC Wakita Laboratory

KEYER1 = PRUSE

This software was developed by the joint research project of Keio University SFC Wakita Laboratory and used to sustain comfortable living spaces by adjusting airflow invisible to human eyes. We could control the understanding of the world. You will witness a superb view hidden in your room through the air conditioner simulation and visualization.

TimeStep: 201 8:43:49

"Visualization of air conditioner" Joint Research - Technology Innovation Center, Daikin Industries, Ltd. and Keio University SFC Wakita Laboratory Credit: Akira WAKITA, Concept and direction Masaki YAMABE, Visualization design and development Futa KERA, development

Yukihiro MORITA, development

Exhibition

"Media Ambition Tokyo 2018" at TOKYO CITY VIEW, Japan (Feb. 9–25, 2018)

This interactive work allowed users to experience a real-time simulation of air by manipulating an iPad and placing objects of any position and size.

2016

Visualization of the ocean general circulation

Keio University SFC Wakita Laboratory, Rhizomatiks Research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

The data used in this work has a resolution that divides the earth's entire surface into grids of about 10 square kilometers. The data also includes the altitude at which the sea surface rises due to inertial forces caused by the earth's rotation and the movement of ocean currents.

By manipulating the zoom, the viewer can observe the large-scale flow of the global ocean and the movement of localized complex eddies. In addition, the visualization of complex ocean currents helps viewers understand the energy of the ocean as a source of weather changes and material circulation.

In this project, I was mainly in charge of analyzing the simulation data provided, designing the visualization for the exhibit, and developing the software.

"Visualization of the ocean general circulation " Credit:

Visualization design and development: Keio University SFC Akira Wakita Laboratory (Akira WAKITA, Masaki YAMABE, Akito NAKANO)

Simulation provider and scientific support: Japan Agency for Marine-Earth Science and Technology (JAMSTEC) Geo-Prism System Development: Rhizomatiks Research

> [Right middle] a visualization for scientific analysis [Right Bottom] prototypes for color variations

A panel discussion: "Resonant Media – Possibilities of 8K Visualization"

Mar. 23, 2021

"Resonant Media – Possibilities of 8K Visualization" is the title of an exhibition that explores the innovative potential of 8K technology, making the invisible visible and swinging into people's hearts at the boundary between art and technology and society. Ars Electronica Futurelab and NHK invite to extraordinary high-resolution insights into future visions of one of today's most advanced technologies. As an alternative to visiting the exhibition on site in Tokyo, the project was broadcast to the world via Ars Electronica Home Delivery live from Deep Space in Linz on March 23, 11 am.

The Berlin-based artist duo Quadrature (Juliane Götz and Sebastian Neitsch), Data Visualization Specialist Masaki YAMABE (JP), Senior Producer Mika KANAYA (NHK, JP), and Roland Haring, Director of the Ars Electronica Futurelab, will embark on a virtual journey to Japan – moderated by Yoko Shimizu, Artist & Researcher in the Ars Electronica Futurelab. After presenting various artistic-scientific approaches connected to the 8K technology and insights into the exhibition, experts were invited to a panel discussion to reflect and discuss the impact of 8K.

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A keynote presentation at the Processing Community Day Japan 2021

Feb. 20, 2021

Processing Community Day Japan is an independent, all-volunteer-organized event in cooperation with the Processing Foundation and hundreds of other locally organized nodes around the world.

In 2021, at the event's opening, I gave a keynote speech on computational information design and behind the scenes of my data-visualization projects with Processing.

youtube: https://youtu.be/HT5Ff4lX4Ds

Contributions to an online magazine on STEAM education in Japan

https://valed.press/_ct/17403101

I contributed a monthly essay on computational information design and creative-coding education to an online magazine on STEAM education in Japan from December 2019 to October 2020.

> "How is the process of visualizing Covid-19 pandemic with 8K." (published: Oct. 23, 2020) https://valed.press/ ct/17403101

"What is fascinating information graphics?" (published: Sept. 25, 2020) https://valed.press/_ct/17394973

化と思考の高い気候
 和は、前常温噌や点と高さ「塗った気」、使用れたととだ作ります、すなら認識、物等温酸
 れに通信・、特等温噌を起きたどかで加い合めりまたいらわせず、
 れのです加いただけではな、
 はなっているかで加い合います。
 れのではなったいとなったのですれただけではな、
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"What is Data Art? – The reason why it makes people enthusiastic." (published: Aug. 7, 2020) https://valed.press/_ct/17382272

Lectures and workshops on computational information design

Since 2007, I have been in charge of creative coding and data visualization lectures at art and design institutes in Japan.

The lecture and the workshop aim to teach visualizing ways to include empathy and human qualities in data. Students develop lots of prototypes with Processing or OpenFrameworks.

Works of Students at Tama Art University, Japan

Works of Students at Institute of Advanced Media Arts and Sciences, Japan

CV

Masaki Yamabe / masakiyamabe.com / contact: masakiyamabe@gmail.com

| | Education |
|--------------|--|
| 2006 2003 | International Academy of Media-Arts and Sciences (IAMAS), Gifu, Japan. A.S. Studied graphic design and media arts. Hosei University, Tokyo, Japan. B.E. Studied computer science and informatics. |
| | Work Experience |
| 2018 - | Self-employed at Design & Programming Inc. Tokyo, Japan |
| 2006 - 2017 | Co-founder and Partner at Alliance Port Inc. Tokyo, Japan |
| 2003 - 2006 | Graphic designer and Interface designer at The Nagahara office Tokyo, Japan |
| | Award |
| 2021 | The grand prix of the annual art award organized by The Visualization Society of Japan |
| | Exhibitions |
| 2021 | Resonant Media – Possibilities of 8K Visualization, Tokyo, Japan |
| 2019 | MADD. Award Screening, Miraikan – The National Museum of Emerging Science and Innovation, Tokyo, Japan |
| 2019 | Oi Oi Oiten – The Exhibition for Wellness and Elderly care, 3331 Arts Chiyoda, Tokyo, Japan |
| 2018 | Japan Society for Graphic Science Autumn Forum, OTSUMA Women's University Tokyo, Japan |
| 2018 | ARIGATO SAKURAGAOKA Produced by ART PHOTO TOKYO, Ex-Yamaha Electone City Shibuya, Tokyo, Japan |
| 2016 | Ocean General Circulation Simulation (for Geo-Prism), Miraikan, Permanent Exhibition, Tokyo, Japan |
| 2009 | Typologic, SPACE NIO, Tokyo, Japan |
| 2009 | DEVICE_ART 3.009, Jedinstvo Factory, Zagreb, Croatia |
| 2009 | Water for Life, Matadero Madrid, Spain |
| 2004 | Ars Electronica 2004 Campus Exhibition, Kunstuniversität Linz, Austria |
| 2003 | MOJITEN@smt – Typography Exhibition, Sendai Mediatheque, Sendai, Japan |
| 2002 | JOUABLE-Exhibition for Playful Media, Ecole des Arts Décoratifs, Genève, Switzerland |
| 2002 | ISEA2002: International Symposium on Electronic Art Nagoya, Warehouse No.4, Garden Pier in the port of Nagoya, Janap |
| 2002 | 02TDC: Tokyo Type Directors Club Annual exhibition, Ginza graphic gallery, Tokyo, Japan |
| | TEACHING |

| 2021 - | Musashino Art University, Department of Creative Innovation, Japan |
|-------------|--|
| 2020 - | Institute of Advanced Media Arts and Sciences, Japan |
| 2020 - | Meisei University, Department of Design, Japan |
| 2016 - 2018 | Keio University, Environment and Information Studies, Japan |
| 2009 - 2020 | Tama Art University, Department of Information Design, Japan |
| 2007 - 2011 | Tokyo University of the Arts, Art Media Center, Japan |
| | |

Biography

Masaki Yamabe is a Japanese information architect, graphic designer, and educator specializing in data visualization. Currently, he is enrolled in the Graduate School of Media and Governance's doctoral course at Keio University SFC. His research focuses on visualization as expressive media. With a computer science and graphic design background, he and his collaborators have created many installations that extract meaningful stories from large and complicated data sets. Recently, he has been working with Japan Broadcasting Corporation (NHK) to create 8K ultra-high definition TV programs for visualizing the spread of COVID-19.

His other works were exhibited at The National Museum of Emerging Science and Innovation (JP), International Symposium on Electronic Art (JP), Ecole des Arts Décoratifs de Genève (ZE), Sendai Mediatheque (JP), Matadero Madrid (ES), Device_art (HR), and Ars Electronica Campus Exhibition (AT). He gave a keynote at Processing Community Day Japan 2021 (Youtube Live).

Since 2007, he has been in charge of creative coding or data visualization lectures at several art and design institutes in Japan.