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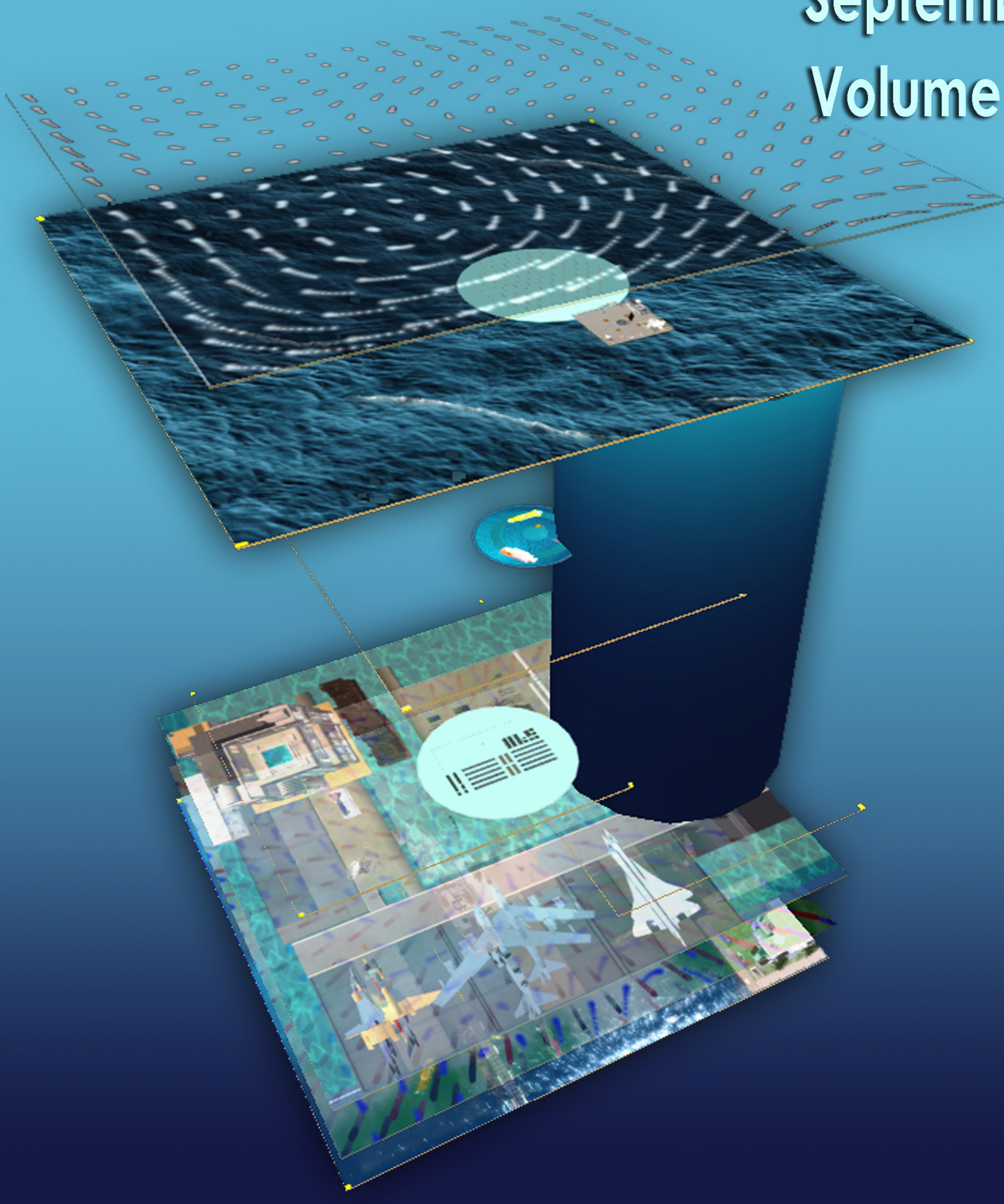

Sky layers of the Abyss

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The Abyss Observatory Designing for Remote Collaboration, Self-directed Discovery and Intuition Development in Multi-User Interactive 3D Virtual Environments

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Abstract

The Abyss Observatory is a museum of Earth Systems Science, Marine Life and Undersea Technology created in Second Life, currently supported by JAMSTEC as a test bed for remote collaboration and 3D visualization to create new scientific value.

First, Second Life is a remarkable platform for remote, interdisciplinary and international collaboration. Second, Second Life has also been useful not only for visualization of such content but also for visualization of the relations between the different content. Such exhibits need to arrange related content in a narrative - not only through linguistic communication (such as text and speech) - but also through visual. For this purpose, we attempt to learn curating methods from Art museums. Third, the Abyss attempts to create new scientific value by assimilation or synthesis of 3D models and data from the real world. 3D models are incomplete but so is data from the real world. For example, deep-sea-life samples quickly changed their shape and color at surface atmospheric pressure. On the other hand, photo and video of such specimens in their natural habitat are also limited in terms of viewing angle and resolution. We are working on 3D modelling of *Bolinopsis infundibulum* which can apply to taxonomic descriptions based on tracking observation of researcher's eyes, and are presently evaluating the scientific value of such endeavors.

Acknowledgment

This paper is the result of collaboration between JAMSTEC, NOAA, The Open University (UK), Science Circle, Digital Hollywood University, Kyoto University and Tokyo Metropolitan University. The Abyss installation itself cannot technically be considered part of JAMSTEC, because strictly speaking the installation comprises sets of objects and each object belongs to its respective creator in accordance with Linden Lab's "Terms of Service". In this framing, the author's (JAMSTEC) objects and other objects which use JAMSTEC data belong to JAMSTEC, but collaborators' objects which do not use JAMSTEC data are independent from JAMSTEC.

We are thankful to Eric Hackathorn of NOAA, Shailey Minocha and Christopher L. Hardy of The Open University (UK), Chantal Snoek and Agustin Martin of Science Circle, Keiji Mitsubuchi and Akemi Mochizuki of Digital Hollywood University, Toshiaki Awaji of Kyoto University, Hidenori Watanave of Tokyo Metropolitan University and Dhugal Lindsay of JAMSTEC.

1. Introduction

The Abyss Observatory (The Abyss) is a museum of Earth Systems Science, Marine Life and Undersea Technology, located in "Second Earth 3" of Second Life (SL). "Second Earth 3" was one of NOAA's SIMs but is currently maintained by JAMSTEC as a test bed of remote collaboration and 3D visualization to create scientific value.

The activities which the Abyss engages in are mainly performed by a team of volunteers from Japan and the USA, helped by many creators from these countries as well as from the UK, France, Colombia, and supported by NOAA, JAMSTEC, SciLands, The Open University (UK), Science Circle and Kira Japan in SL.

The current purposes of the Abyss are both the popularization of Earth and Ocean research activities as well as to serve as a research test bed of JAMSTEC. In this paper, we describe our design considerations and research orientations at the Abyss.

2. Collaboration

2.1 Major Factors for the Affordance of Collaboration in Second Life

The original "Abyss Museum of Ocean Science" was created by avatars Rezago Kokorin and Sunn Thunders; this was closed in March 2009. A second attempt at an ocean museum started later that year in August as a garage-factory exhibition of ocean measurement instruments by Japanese volunteers with the support of a private homestead owner. In December 2009, SciLands and the NOAA adopted to support the Abyss at one of NOAA's regions. With the meeting of minds of good creators, scripters and artists, the Abyss is gradually developing and has now become a full-region museum under the support of JAMSTEC since April 2011.

This history shows Second Life to be a remarkable platform for remote, interdisciplinary and international collaboration, overcoming differences in language and time zone. Major factors for such collaboration are derived from:

- Remote and real-time / non-real-time communication by English text chat: Listening to English can be a weak point for Asian people. English text chat enables Asian people to communicate internationally at relatively ease. It is also more useful for conferences during which many people are participating.
- Second Life object-oriented creating method also enables to share works or ideas and to accumulate collaborating results in non-real time. People do not need to rely upon Computer Graphics specialists in order to express their own ideas in Second Life. There are many free materials for creation, and an active marketplace in which people can easily purchase goods and use them in Second Life.
- We also need to consider that Second Life behaves less like a single large city, and more like a world comprised of ever-spreading villages. It can be argued that this attribute has been

challenging for private companies to appreciate, as many have misunderstood Second Life to be similar to other forms of mass media.

The Abyss also exists on an OpenSimulator grid under collaboration with Chantal Snoek's "Science Circle". The present authors consider that the preceding factors might yet be applicable to OpenSimulator in the future; however, at the present moment OpenSimulator grids are immature in terms of community size and compatibility of script language. The absence of a common marketplace is also a weak point of OpenSimulator grids.

2.2 Consideration for Accessibility

A major difficulty in terms of visiting museums and places of education in Second Life – from the point of view of Asian residents – is that general dearth of bi-lingual or multi-lingual signs and notecards; this is in sharp contrast to real life, in which multi-lingual signs are common in major cities. In the Abyss, signs, notecards and newsletters in both Japanese and English are available by default. We would like to invite other science museums to collaborate with each other in terms of increasing their multi-cultural outreach.

The Abyss also considers users of low performance Personal Computers and / or networks. To reduce loading time of textures and polygons within draw distance, exhibition floors are dispersed from ground to 4000 m altitude in the sky (Fig-1). But this consideration induces difficulty of navigation or way-finding. There are many restrictions and required conditions for each exhibit floor location, and in addition, we clearly separate the Science zone from the Fantasy zone, and the Art gallery from the Design gallery to avoid confusion. Therefore, viewing routes run the risk of becoming less apparent.

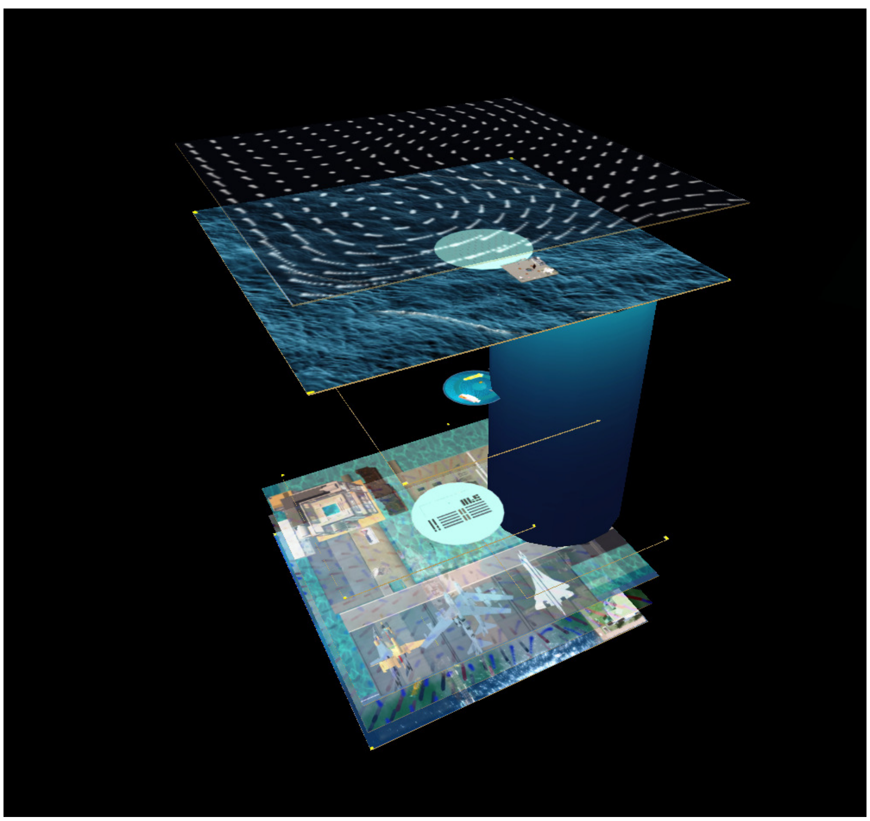

Figure 1: Sky layers of the Abyss (Vertical is one tenth of horizontal)

The Open University (UK) has contributed to the improvement of navigation by simplification of viewing routes and color coordinated signs (Minocha & Hardy, 2011). Visual communication is also important as discussed in more detail in the subsequent section.

3. Visualization of Relation

3.1 Curating

In terms of the "Visualization of Relations", the Abyss has various exhibitions as follows;

- **Submersible History**: The Abyss displays "Ictineo I" (1859), Beebe & Barton's Bathysphere (1930), Bathyscaph "Trieste" (1953), “Submanaut” (1956), Diving Saucer "SP-350 Denise" (1959), Harvor Branch’s submersible "Clelia" (1976), “Shinkai 6500” (1989), “Deep Flight” (Current), Near future submersible and Far future Fluttering Submersible. We can display them not on the museum floor but in the sea. This is easy to do in Second Life, but if we were to attempt to construct such a museum in the real world, we would need access to vast funds for construction and further for maintenance. We should not underestimate such a scientific affordance of Second Life.
- **To predict climate change**: The Abyss displays Research vessel “Okeanus Explorer”, *In situ* ocean observation system (Buoy, Glider, ROV, AUV, OBS, OBEM), Atmosphere observation equipment (Doppler Radar, Wind Profiler, Radiosonde, Middle- Upper Atmosphere Radar, GPS-Receiver, AWS), Satellite observation and Supercomputer “Earth Simulator” (NEC SX-9/E 160 nodes). We displayed these objects *in situ* while mimicking their respective movements.
- **Captain Nemo’s Nautilus**: The Abyss exhibits very realistic submarine “Nautilus” faithfully reconstructed based on Jules Verne’s “20,000 leagues Under the Sea”. Researchers of Verne believe the novel was written based on drawings of Nautilus although they were never discovered. Many readers tried to reconstruct Nautilus design but avatar Reitsuki Kojima provided a most excellent answer by a real-scale reconstruction in Second Life. He found that there are three more small rooms which are not mentioned in the novel. This example shows the affordances of Second Life of not only synthesizing information from a diversity of sources, but also reconstructing arrangements derived from these syntheses.
- **Marine Ecosystem**: We are constructing a shallow water ecosystem - coral reef and undersea plant-bed to express relations between marine life and their environment. We intend to arrange seaweeds, reef, crabs, shells, starfishes, fishes and other animals depending on sea bottom (sand or rocks), sea water temperature and depth, cognizant of territories of each species and the food chain (Fig-2). We can arrange predator-prey combinations – this is something which is impossible in a real aquarium – such as Ocean sunfish and Jelly fish, Octopus and Moray, Orca and Seal, etc.

Video is most useful for understanding such spatial relations, but there is not enough of such information. So we seek more collaborators who advise us about ecosystem relations.

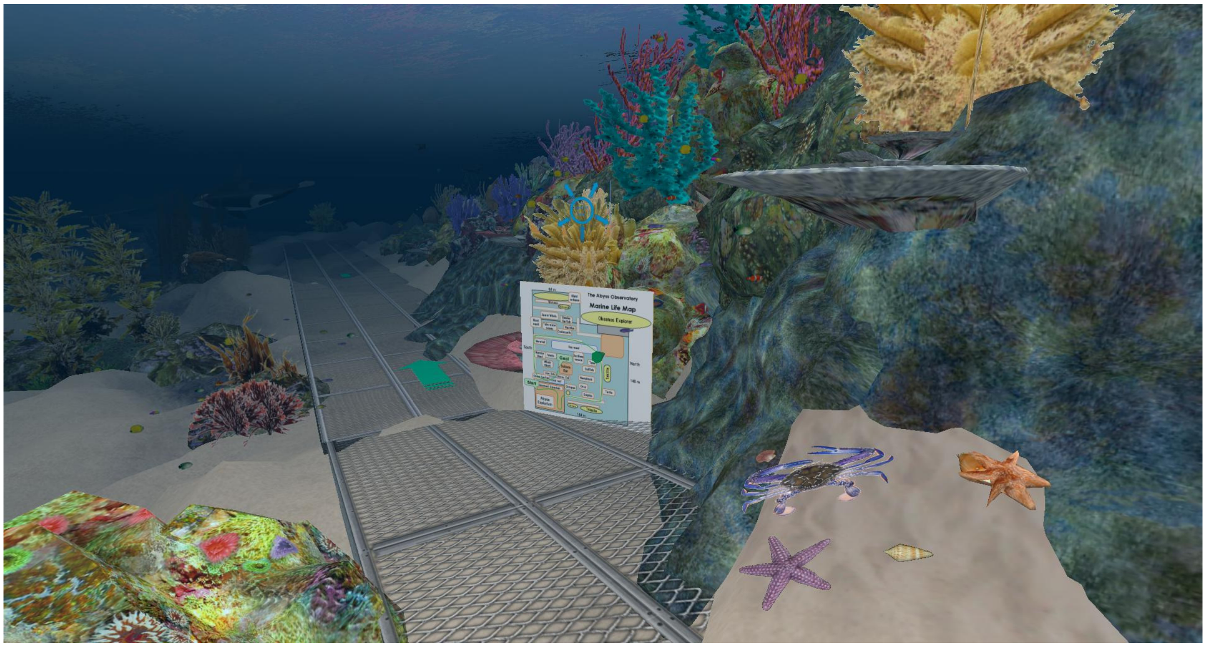

Figure 2: Coral Reef Exhibit in The Abyss

Such exhibitions need to visualize not only each subject but also the relations between content. These exhibits also need to express a narrative not only by text sentences but also by arrangement of content in space.

Humankind has developed rhetorical thinking skills but we have not fully developed effective visual thinking skills (Ware, 2008), particularly in the natural sciences. The present authors seek to extend the definition of "Curation / Curating" beyond simply an "arrangement of contents only" towards "situating contents under some context and to visualize some relations by arranging them in space for creating new intellect such as surprise, originality, etc." (modified from definition by Toshinao Sasaki, Jun Masuda and Kazuki Yokota.)

Visual data exploration can be seen as a hypothesis generation process (Keim, 2002): The visualizations of the data allow the user to gain insight into the data and come up with new hypotheses, which make 'information' from 'data'. The verification of the hypotheses can subsequently be done via visual data mining, which make 'knowledge' from 'information'. The Abyss is trying to learn curating methods from Art museums.

3.2 Navigation and Way-Finding

For this purpose, navigation and way-finding design in museums is very important. This is also a key point to provide self-learning places in virtual environments and fictive worlds. The Open University (UK) and the Abyss have been collaborating on navigation and way-finding since July 2010 (Minocha & Hardy, 2011). As a result, we have established some empirical design rules for the Abyss:

- Divide viewing route into several mini-tours depending on themes. We set the central hub as a portal to five destinations: "Info & Sky Gallery" (yellow), "Marine Life & Human under the Sea" (green), "Journey into the Deep" (blue), "To predict Climate Change" (orange), "Sunken City and Fantasy Zone" (pink). (Fig-3)
- In each mini-tour, set viewing route as traversable.(Fig-4)
- Set enough guide signs and arrows of theme-color of each destination: Visitors do not like to get note cards and jump to Web page, or to use Tour-ride. It is also difficult to introduce exhibits

which incorporate vertical teleportation. So we are to basically depend on classical method - Guide sign arrows. Guide arrow on the floor is useful in virtual environments and fictive worlds.

- Set enough teleporters for “Exit to Central Hub”.

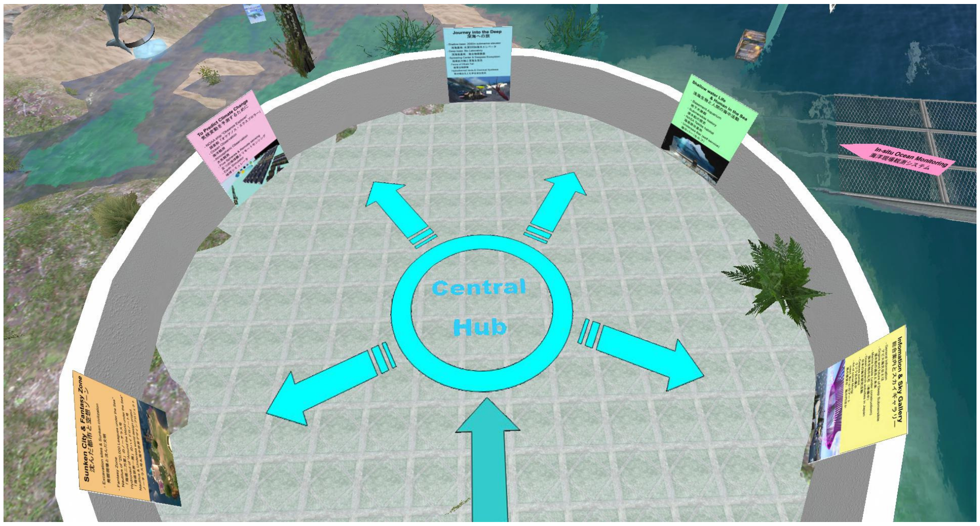

Figure 3: Central Hub and portals to five destinations

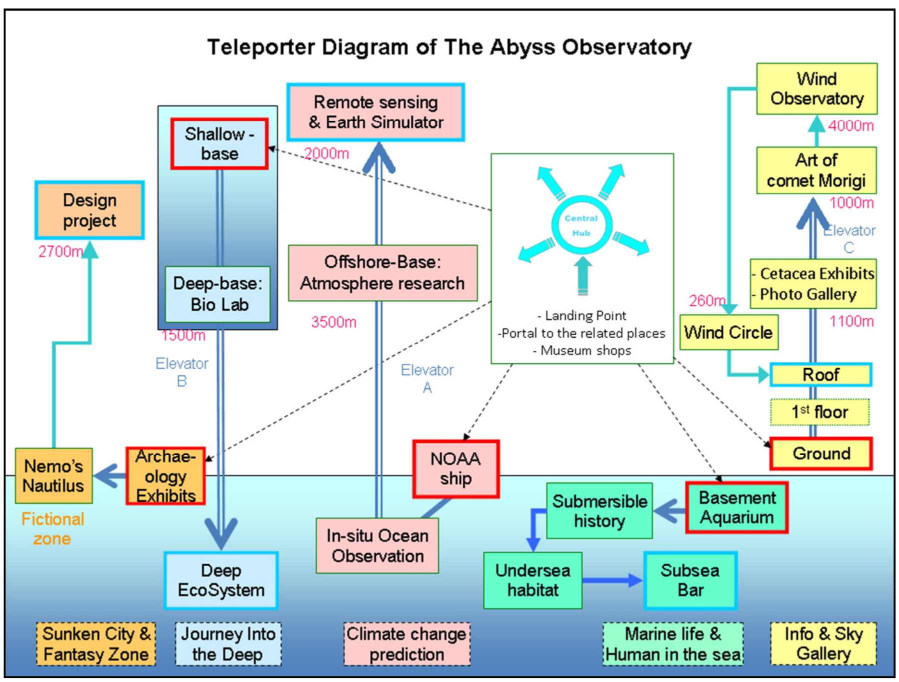

Figure 4: Teleport diagram of five destinations

4. Fusion of 3D Model and Data from the Real World

4.1 Model vs. Data from the Real World

The third aspect of our work at the Abyss is to create new scientific value by assimilation or synthesis of 3D modelling with data from the real world. Bach and Mauser have established procedures which assimilate remote sensing data into geometric models of complex regional land surfaces (Bach & Mauser, 2003). In the weather prediction research area, the data assimilation technologies have been utilized in order to improve the quality of the ocean-atmosphere coupled-model with existing observation data.

In the same way – with a nod to Schrödinger's Cat – deep-sea-life samples change very quickly in color and shape once recovered to the deck of a ship. On the other hand, deep-sea photos and videos are also incomplete because most photos and video are not high resolution due to scientists preferring to find as many species as possible, and it is not possible to change view angle and view distance of photos and video once the footage has been captured. So if we can synthesize 3D model and data from the real world, the result can create new scientific value.

As a corollary of the argument in the preceding paragraph, "virtual" becomes an inadequate term because scientists think "virtual" is "not real" and thus that "virtual" has no scientific value.

3D modeling of samples by laser scanning is a common methodology of science in many research fields, such as Archaeology, reconstruction of fossil, etc. But there is no laser scanning technology for soft bodied semi-transparent creatures in water. So we are working on 3D modelling of *Bolinopsis infundibulum* which can apply to taxonomic description using Unity3D environment with JAMSTEC and Digital Hollywood University, based on tracking observation of researcher's eyes, and are presently evaluating its scientific value. (Fig-5)

Researchers have detailed images in their own minds but we found it is very difficult to communicate these mental images with the content-creators – even for seemingly simple structures as jellyfish. Still photos are not useful to identify complex 3D structures. There may be individual differences between even the same species in each photo. Video is more useful but video angles are usually limited in deep submersible or remotely-operated-vehicle operation. Researchers can assemble taxonomic descriptions from various sources of information, but they do not have the techniques to express these as sketches. Instead, recourse is needed to clay or wire. As such, interactive 3D visualization is a critical technology for taxonomic or scientific research.

There is another problem with even simple structures as jellyfish: when we attempt to use traditional 3D software to model water pipes or organs inside the body such that they might be zoomed in to, polygon numbers expand to the extent so that they become impossible to render in real time. Simplifying or symbolizing each part and assembling them together is an essential technique that we always experience in Second Life.

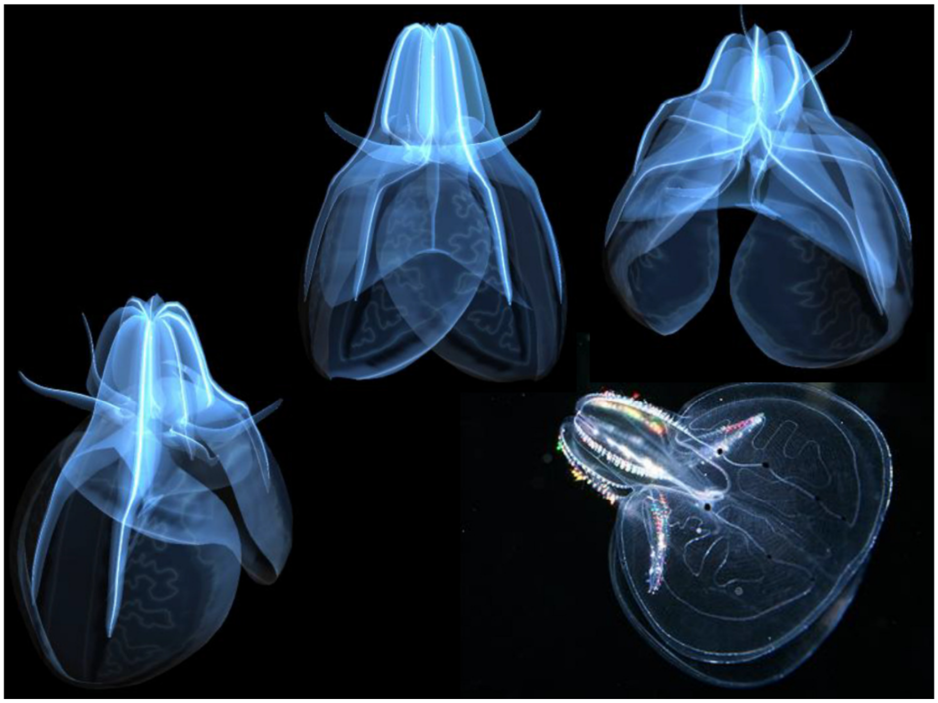

Figure 5: Real photo of "Bolinopsis infundibulum" (right side down) and its 3D model we are working on (others)

4.2 Visualization for Self-Directed Discovery and Intuition Development

A variety of computer simulation techniques can be conducted in 3D environments. Results from these simulations are conveyed to people through visualization. As well as the simulation technologies, such visualization is important for inspiration and the development of intuitive proto-understandings. An effective visualization helps people to deepen their thinking and start their mutual conversation, which will become a key to self-directed discovery and intuition development (Koyamada, 2011). We suggest the following three features of 3D environments, in terms of self-directed discovery and intuition development:

- **Manipulable points-of-view:** Zooming-in and zooming-out from arbitrary positions and angles is a principle requirement of visualization for research. In addition, Second Life is a visualization platform upon which persons of various skills can observe a given research object from multiple points-of-view. To make transparent or cut-out, to see time variation, to superpose various data, etc. - are potential developments for future enactment.

It is easy to get the (false) impression from high-quality Hollywood movies of that any kind of visualization is straightforward to produce. But "movie" and "interactivity" are quite different. Hollywood movies are produced after a very long rendering process. Cinematic audiences passively watch playback in a unilinear manner. If people want to observe and manipulate objects interactively, real-time rendering and real-time simulation are needed. Currently, real-time rendering can be carried out by the graphics processor of the computer. But color mapping for rendering depends on both the character of objects and on human senses, so optimization of color mapping needs much time and expertise.

- **Geo-spatial mapping of time-sequenced data**: Another point for research is data mapping. GIS as represented by Google Earth is rapidly spreading across various fields, but it is not established as a mapping platform for time-sequenced 3D products. One of our collaborators, Hidenori Watanave, is creating "The Dynamic East Japan Earthquake Archives" using the Google Earth

API and trying various kinds of data mapping including satellite images before and after quakes, photos overlapped with 3D geographical features and 360-degree panorama images. YouTube video can be also mapped but this has not been pursued out of respect to the suffering of the victims (Watanave, 2011) (Watanave, et al., 2011).

Another collaborator, Keiji Mitsubuchi, created East Japan on a scale of 1:1,250 by using two full regions of Digital Hollywood University in Second Life. Kenji also mapped web-based data on Second Life topography and used this place for collaborative creation by students.

- **Developing intuitions through observations and experiments**: the physics engines in Second Life are Havok 7 and Havok 2k10 (the latter is still in beta). Students can easily perform observations or experiments to develop intuitions about laws of physics using seesaw (Fig-6) and the Leaning Tower of Pisa – the latter would be just like what Galileo himself performed.

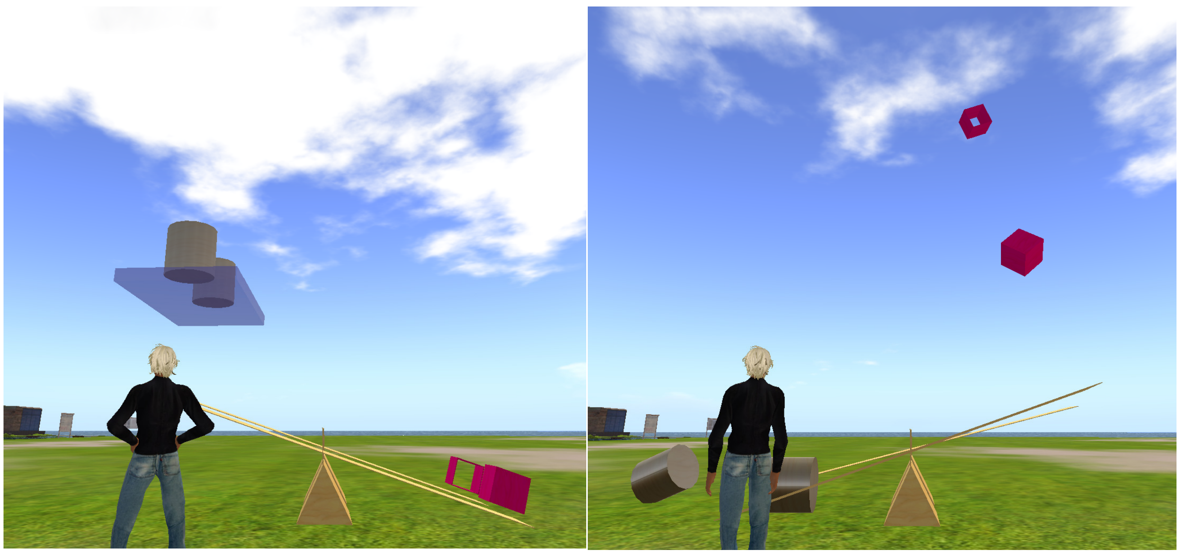

Figure 6: Developing intuitions through Seesaw experiments in Second Life

Left: Initial state. Right: After dropping weights. Note that the vacant box jumped higher than the solid box.

Students can also visualize wind-fields in Second Life. Such normally invisible multi-dimensional phenomena are actually simulated in real-time in Second Life through equations involving two-dimensional uncompressible fluids. The Abyss displays two Art installations which permit the visualization of wind through the use of particles and flexible tubes (Fig-7). Students also can surface their preconceptions and assumptions of the Solar-Earth-Moon system model of Second Life, by observing the movement of the stars, sun and moon from various places across the Second Life grid. They could then compare astronomy in Second Life with astronomy from the real world, in an investigative epistemic frame similar to how Galileo carried out his own observations and experiments.

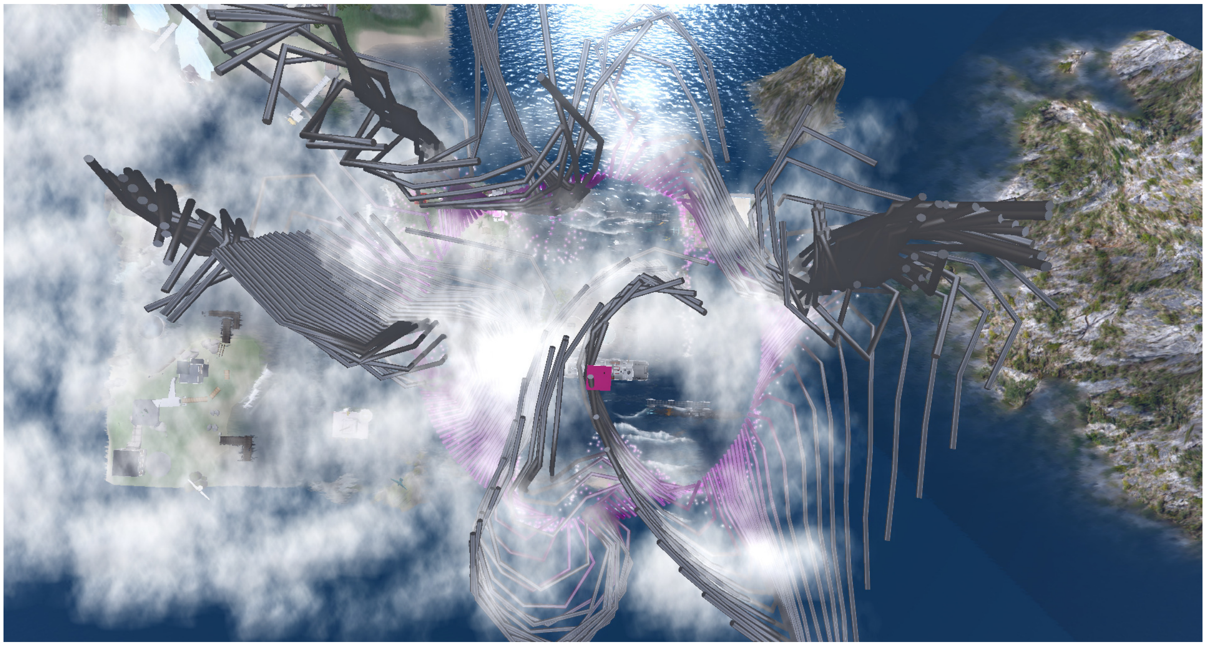

Figure 7: Wind Circle by avatar Artist, comet Morigi

We are studying above three attributes on Google Earth and Second Life with other platforms (OpenSimulator, the Blu, Unity3D, CAVE, etc.) and extracting requirement for future visualization platform for remote collaboration and self-directed discovery.

5. Conclusion

Taking into consideration issues of low performance Personal Computers and networks, improvements to navigation and way-finding, bilingual – multilingual standards, visualization of relations and curation, syntheses of 3D model and data from the real world, this paper has described the use of the Abyss as a test-bed with many collaborators.

References

Bach, H. & and Mauser, W. (2003). Methods and Examples for Remote Sensing Data Assimilation in Land Surface Process Modelling. *IEEE Transactions on Geoscience and Remote Sensing*, 41(7).

Colin Ware, C. (2008). *Visual Thinking: for Design.* Burlington, MA. Morgan Kaufmann.

Keim, D. A. (2002). Information Visualization and Visual Data Mining. *IEEE Transactions on Visualization and Computer Graphics*. 8(1).

Koyamada, K. (2011). An Effectiveness Verification Method for Visualizing a Disaster Simulation. *Proceedings of International Symposium on Disaster Simulation & Structural Safety in the Next Generation* (DS'11).

Minocha, S. & Hardy, C. L. (2011). *Designing navigation and wayfinding in 3D virtual learning spaces*. In: OzCHI 2011 Design, Culture and Interaction. Australian National University, Canberra, Australia.

Nishimura, H. The Abyss Observatory. http://aquarobo.com/abyss/

Watanave, H. et al. (2011). "Nagasaki Archive": Plural Digital Archives That Urges Multipronged, Overall Understanding about Archived Event. *Journal of the Virtual Reality Society of Japan*, 16(3), 497-505.

Watanave, H. *The Dynamic East Japan Earthquake Archives.* Retrieved from: http://colabradio.mit.edu/the-dynamic-east-japan-earthquake-archives/.