Abstract.
In this paper, a methodology called “reverse distributed computing” will be introduced. Second Life provides a means to conduct experimental research in a way that reduces barriers related to physical space and conceptual understanding. An emerging example of this is the author's own Second Life location (the Media-based Computation and Natural Systems Lab). This is comparable to distributed computing, which harnesses the power of distributed networks for the analysis of data. With the right interface and hardware, collectively referred to in the paper as “Media-Based Computation”, participant-oriented experiments may be possible that are equivalent and perhaps supersede what can be accomplished in a fixed, centralized environment.

Introduction.
In information technology terms, Second Life is the marriage of virtual environments, which utilize avatars and physics simulations, with the Internet, which provides opportunities for distributed processing and human interaction. The author is heading up a Second Life initiative called the Media-based Computation and Natural Systems Lab [1] that will serve as an ongoing experiment into virtual world approaches to scientific experimentation. A recent article in Science [2] has espoused the benefits of virtual environment to social scientists. This paper serves as an addendum to that article; virtual worlds can also play a vital role in other areas of scientific research, and may provide novel avenues of visualization and investigation to researchers, educators, and students alike.

Second Life Labspace.
The Media-based Computation and Natural Systems (CNS) Lab is currently under construction. The foundation of the CNS lab was built between July and August of 2007 on an “island” provided by Nature Second Life [3]. The lab is located on a peripheral island between the SciFoo space and the large interactive cell. If one visits the lab circa September 2007, there are no permanent exhibits. However, research is being done offline in the realm of physical-world and virtual world physics engine-based application. Thus, the examples discussed within are largely theoretical. However, the technologies currently exist to make the potential applications discussed within salient.

Second Life Potential: a cue from other virtual environments.
While many people are interested in the potential of Second Life as a tool for social science research, research traditionally done in other non-networked virtual environments may provide a basis for future technical milestones in Second Life. Examples of this may include protein modeling, population-level simulations such as wasp colonies and urban development, and distributed data analysis.

Participant-oriented science experiments can also be done in Second Life. Ultimately, given the proper hardware and software modifications, a visitor to the CNS Lab will be able to experience topics such as evolution, computation, and physiology as never before.

Media-Based Computation in the Context of Second Life.
In the context of this paper, the term media-based computation describes interactions between physics-based simulation, human interaction, and experimental subject matter. In this case, human interaction involves the mapping of physical behaviors and physiology to a virtual space. For example, motion controllers such as the Microsoft Wiimote may be used in conjunction with the Second Life environment [4], and can be used to provide both kinematic and kinetic mappings between simulation participants and experimental
environments. It is of note that the gap between user and avatar is narrowed using interfaces such as these. Tight control over this mapping is an essential element of delivering the promise of Media-based Computation. Similarly, physics-engine or evolutionary computation may allow for processes such as physiological adaptation and biological evolution to be mimicked in a virtual setting to a reasonable extent.

Natural Systems and their Importance to Second Life.

Natural systems can involve the interaction of both physiological systems and physical environment parameters such as water columns and atmospheric pressure. In the case of a Second Life-like medium, these environmental parameters can either be native to the virtual environment or mapped back and forth between the physical world and a computational engine. In the case of evolving artificial organisms such as virtual deep sea fishes, the former is the case. In the case of translating standing physiological states of a human subject to a virtual avatar, the latter is the case. In all applications, however, there is a necessary mix of native computation and translational mapping that must take place.

Examples of “Transparent” Experiments.

A media-based computational experiment can be considered “transparent”. This is because in the ideal application many of the manipulations and processes should be intuitively obvious to any visitor who participates. Below are two potential examples of such experiments, one directly actively involving a human interaction, and the other which involves passive human interaction.

Example #1: extreme environments immersion tank.

The first implementation currently on the drawing board at the CNS lab is a real-time experiment demonstrating the effect of extreme environments on the human body. In the experimental setup, an avatar would enter a long tube or tank, the depth of which would serve as an environment gradient. As the participant's avatar moves deeper into the length of the tube, several parameters representing variables such as atmospheric pressure, temperature, and medium would increase or decrease accordingly.

There are several potential ways to capture information about the changing environmental parameters. One way is to use an alphanumeric readout located somewhere on the screen. A set of gauges on the lower right-hand side of the screen would “simulate” the effects of multiple variables. Readings would inform the participant what the effects of such exposure represent in

Second Life Science: the potential for “reverse” distributed computing.

Besides endowing the avatar with physical world control capabilities, Second Life allows for new forms of the distributed computing paradigm. The most famous example of distributed scientific computing is the SETI@home project. SETI@home involves the distribution of data packets containing portions of a massive dataset to remote client machines for analysis [5]. In this paradigm, the author is proposing what might be called “reverse” distributed computing: individual visitors coming to a centralized site to participate in an experiment. Like the case of distributed computing projects, where Internet connectivity and remote terminals were used in lieu of a supercomputer for the analysis of data, reverse distributed computing pulls human expertise, observation, and variation towards the locus of computation. A centralized experiment with the results available for all to see is computationally more efficient than science that occurs in closed quarters or results that languish in a library.
terms of bodily deformation or stresses on the body. Thus, the “avatar” may serve as an artificial lifeform. Future implementations might even allow for the avatar's body to deform, much like a Gumby doll.

![Figure 2. Beginnings of a pressurized tank (blue glass frame in foreground).](image)

**Benefit of Using Second Life for Extreme Environments Immersion Tank.**

In this example, a variety of individuals could experience and participate in an experiment once limited to a physiology laboratory. There should also ways to map individual-level variation to the avatar in order to provide some connection between the participant and the simulation of human physiology. Given baseline physiological measurements for each participant, the interface could be calibrated to each person participating in the experiment and demonstrate changes to the human body that would translate into understanding for the participant.

**Example #2: demonstrating evolutionary processes in deep-sea fishes.**

The second implementation on the drawing board at the CNS Lab is an exploration of deep sea fish anatomy and physiology. Deep sea fishes are used as an example of organisms that adapted to deep sea environments that may have evolved from ancestral forms originating in shallow, coastal environments.

The object of this simulation is to observe a "population" change over from ancestral pelagic fishes to derived deep sea fishes as environmental parameters within the tank change. The participant will be able to watch evolution “in progress” through a time-elapsed overview of fish phylogeny. As with the first example, changes in the set of environmental parameters will be visualized for the benefit of the participant.

As currently envisioned, phenotypic change is elapsed over both generational and developmental changes. As currently planned, the deep sea fishes would constitute a single population of digital organisms change their appearance according to changes in the proportions of positively-selected genetic representations over time in response to environmental selection. While this is not the way Artificial Life simulations are typically carried out, for purposes of this application it is sufficient.

![Figure 3. View from enclosed gallery of future fishtank (inside of tank is beyond glass with gravel flooring).](image)

**Benefit of Using Second Life for Demonstrating Evolutionary Processes in Deep-sea Fishes.**

With this experiment, there is an opportunity to observe adaptation as it happens, in a way not necessarily possible in real-world experimentation. The key components of this are 1) time-elapsed morphological change and 2) the ability to examine a virtual model of the morphology before and after adaptation.

**Conclusions.**

These two potential experiments represent the range and scope of what the members of the CNS lab eventually hope to accomplish. What has been presented here is intended as a rough sketch for
a broad audience. As members of the CNS group develop new tools and further programming proficiency in Second Life, the content of these examples are subject to change. This is especially true as the ideas briefly presented here become more developed in an application sense. Ultimately, we would like to be able to do simulated physiology experiments online in a Second Life environment.

Finally, the advantage of using Second Life boils down to logistics; doing realistic but in simulo science with people from all walks of life greatly augments textbook and “crowd around the bench” type approaches. Real-time action interfaces such as physiological state monitors and the Wiimote also provide a telepresence [6] aspect that anatomical diagrams and cartoons on a CD-ROM do not accomplish.

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References


