Multimodal Interaction, Medial Arts and Education
A case applied in the multimodal learning of bioinformatics concepts and the visualization of biological data

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Abstract

Bioinformatics and computational biology seek to apply computational tools mainly to make decisions based on the visualization of the biological data [1]. For this reason, it is now stated that both belong to the group of sciences with greater projection in the acquisition of scientific knowledge [2], which will bring with it and globally, a crucial change in biological research [3]. This rapid scientific progress suggests that bioinformatics will play a fundamental roll in our daily lives and in this sense, interacting, visualizing and learning about the manipulation of these biological data gradually becomes more relevant to enhance the public domain of this knowledge. In a mega biodiverse country such as Colombia, learning the princi-ples of bioinformatics is essential for the public to make informed democratic decisions about the benefits and perceived risks associated with bioinformatics. Educational interventions based on project research to expose students to biological data are urgent to meet these needs.

Keywords

Multimodal interaction, multimodal learning, biological data visualization, medial arts, bioinformatics, education

Introduction

These sciences (Bioinformatics and computational biology) study molecular biological structures such as genes and proteins, which come from a sample and are converted into discrete data for analysis. The visualization of these macro structures cannot be drawn with pencil and paper that is why computational tools are necessary for visualizing them and to learn how they works.

Human learning can be described as a multimodal perception experience, where senses help human beings to apprehend concepts, skills and meanings. In this perception process, sight linked to the visual cortex as the sense with greatest incidence in the capacity of our brain to store information [4] works together with hearing and kinesthesia in order to generate a greater quality in the learning experience.

How to generate greater learning processes in bioinformatics combining multimodal ways of cognition and multimodal technology experience, is central to this paper.

The key aspects to structure critical learning about the basic concepts of bioinformatics lie in the reflection on the composition of molecular macrostructures and the understanding of the impact their visual representations have on the making of decisions.

To expose the student to an environment communicating these aspects, two contrasting scenarios are defined:

First, they have to complete the process, from DNA extraction, the intervention in a sequencing process, the analysis of contrasting aspects in the recording and the analysis proper of the visualization of data. Second, they will have a confrontation to real cases so that they judge and make decisions on the manipulation of this information. The possibility of advancing in the resolution of these scenarios resides in the appropriation of the scientific process and the ability to judge and to make decisions on the possibilities.

Palmerius [5] identifies at least four relevant actors who play a role in designing and implementing the virtual environment as a platform for interaction and user learning:

- Scientific understanding
- Task Scenarios
- The actual user interaction
- The theory of interaction design.

The approach of this project is novel given that in the case of bioinformatics, although there are platforms for engineers to interact in a game-like mode with protein chains and even some apps that teach the basic pairing of DNA, there is not much availability of

learning virtual objects in Spanish that allow students to interact with the visual representations of these data and learn how to make value judgments about the use and manipulation of this information.

Sections

The sections below, describe the process in the development of a multimodal educational environment prototype to learn the principles of bioinformatics through different visualization and interaction tools. The methodology includes a preliminary exploration process in the design of interactions, which will later lead to a simulation of the process of bioinformatics analysis scenario from sampling, sequencing, and recording, in order to give sense to the visual representations of this information.

Multimodal Learning.

It has two ways to be applied in this context. [6] On the one hand, the semantic multimodality of concepts, understood as the multiplicity of languages, signs and symbols that can account for a concept is found. On the other hand, the technological view as the combination of different devices or channels to deliver the message or give a sensory stimulus is found. The research question asks for the impact in the interaction between semantic and technological multimodality for the creation of a digital learning environment in bioinformatics issues.

On multimodal semantics, the content was presented to the students using partially visual and auditory modes in Mousavi's experiment [7]. The split attention effect suggests that it is possible to expand the memory capacity when working in a dual or multiple mode to display the information.

This statement was confirmed by Tindall-Ford and Mayer and Moreno [7] who worked on the line of cognitive load theory, which assumes a limited memory of work in which all conscious learning and thinking occurs, and a long-term practically unlimited memory that carries out many automated schemes that can be entered into the working memory for processing. Oviatt [8] applied these results to design the interface of education in testing several different principles and strategies of user-centered design, demonstrating that the UI design that minimizes cognitive load can free mental resources and improve students' achievement. One of the strategies to achieve this is the design of a multimodal interface for students.

In addition to the theory of cognitive load, the short-term memory model of Baddeley & Hitch [8] is added, which has 3 main components:

- The central executive: controlling the flow of information
- The phonological loop
- Visuo-spatial canvas
- Auditory-verbal information
- Visuo-spatial information

This model was developed from an experiment to perform 2 simultaneous tasks where it was possible to conclude that human performance per se is improved when interacting with two modalities that can be co-processed in independent storage.

On the other hand, Palmerius et al. [5] designed a system of multimodal interaction to accelerate the learning about subjects related to nanotechnology.

The problem with their study was to make understanding around nanotechnology topics able to match the speed at which these developments are produced and installed in the world around us. The circuit included:

1. Immersive 3D Technology
2. Hand Detection and Interaction
3. Haptic Technology
4. Audio Technology
5. Nanoparticle Simulator
6. Motion and Dynamics of Nanoparticles
7. Flexing of Nanotubes
8. Short-range Inter-particle Interaction
9. Solvent Interaction

Interaction Design Technical Exploration.

In the experimental creation of interactive environments 2 scenarios of multimodal interaction have been developed: one was exposed in the Book Fair 2016 and the other for the GILABI Acid Lactic Bacteria Research Group and its industrial biotechnological applications of Universidad Nacional de Colombia. These scenarios allowed exploring the creation of interactive spaces with different mixtures of technologies from the guidelines for the development of a multimodal interface [8] by Bruno Dumas, Denis Lalanne and Sharon Oviatt. These environments included:

1. App of augmented reality that allowed visualizing 2D and 3D objects in relation to a reading in addition to the direct download of reading texts.

2. Video cabin
3. Audio books section
4. Interactive reading with kinect
5. Interactive reading by voice power that activated a lighting system
6. 1 transmedia infographics

Figure 1. Short sample from technical exploration.

Semiotic Cognition and Technological Multimodality.

Once the technical possibilities were experimented, the experimentation of interactive design that dialogues with the semiotic multimodality of concepts followed. To that end, a methodological practice of design thinking was formed as an interdisciplinary group composed by 2 thematic experts in bioinformatics (PhD and magister), a social communicator, a visual designer, 2 system engineers, an expert in pedagogy and a design researcher.

The proposed methodology is based on the one described by Zimmerman, in which the interaction designer, in this case the researcher in design, channels the information to create the interactive artifacts; added to this aspect, design researcher has to resolve the conversion from a classical semiotic cognition to multimodal technical possibilities.

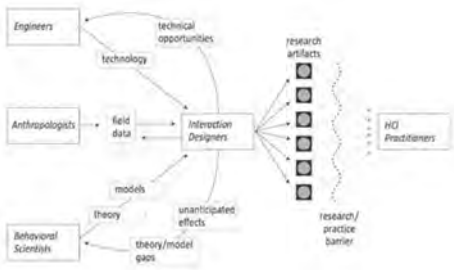

Figure 2. An illustration of the pathway and deliverables between and among Interaction Design Researchers and HCI Researchers. Zimmerman.

Future Work

The development of the described system is part of an ongoing project focused on the study of visual and interactive systems for teaching concepts in bioinformatics to be applied in the transfer plan of the Wall of Visualization of scientific data available to the city in the Bioinformatics and Computational Biology Center of Colombia. For this purpose, a system has been projected with some central capabilities: Immersive 3D graphics with interactive simulation of the structure of a protein with kinetic and auditory feedback. This system takes advantage of the available local technological infrastructure as a result of the strengthening of training and knowledge management capacities. The contents are designed to run on other platforms as well, allowing their use depending on the learning situation.

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Author Biography

Born in Manizales on July 29, 1989. She graduated as a professional in Mercadeo Nacional e International and since, her last practice has been working in the digital marketing sector. There she led the development of projects such as Project manager related to web pages, applications, video games and multimedia content development for various platforms. In parallel, she studied a technology in Graphic Design and participated in technology and innovation scenarios such as startups + and CampusParty. At the end of the studies on graphic design, she started working at the Bioinformatics and Computational Biology Center of Colombia BIOS, to be part of the marketing and communications team. There she became involved in communication practices of science and market studies of the biotechnology sector in the region and the country. Based on these lessons, a strong interest in the relationship between design, art, science and technology was consolidated, also discovering that there is a strong lack of knowledge of the use of this technology in the local environment of the country while in the world some sustainability practices involve this technology as a tool to evolve and seek alternative adaptability towards the future.