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DNA Encoding Training Using 3D Gesture Interaction

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Abstract. The work described in this paper summarizes the development process and presents the results of a human genetics training application, studying the 20 amino acids formed by the combination of the 3 nucleotides of DNA targeting mainly medical and bioinformatics students. Currently, the domain applications using recognized human gestures of the Leap Motion sensor are used in molecules controlling and learning from Mendeleev table or in visualizing the animated reactions of specific molecules with water. The novelty in the current application consists in using the Leap Motion sensor creating new gestures for the application control and creating a tag based algorithm corresponding to each amino acid, depending on the position in the 3D virtual space of the 4 nucleotides of DNA and their type. The team proposes a 3D application based on Unity editor and on Leap Motion sensor where the user has the liberty of forming different combinations of the 20 amino acids. The results confirm that this new type of study of medicine/biochemistry using the Leap Motion sensor for handling amino acids is suitable for students. The application is original and interactive and the users can create their own amino acid structures in a 3D-like environment which they could not do otherwise using traditional pen-and-paper.

Keywords. Amino acid, leap motion, 3D images, gesture.

1. Introduction

In order to learn the 20 amino acids resulted from the combination of 3 or 4 nucleotides from the DNA (adenine –A, cytosine – C, guanine – G and uracil – U or thymine - T), the medicine, chemistry or bioinformatics students or the human genetics domain studying passionate people, use domain related books or solve exercises on paper, which are not interactive.

The main objective of our work was the development of an application for students that learn the amino acids in a new interactive manner, through gestures and viewing in a 3D environment.

An amino acid is the result of the translation process. The 20 amino acids formed by the combination of the 4 nucleotides are the following: alanine, arginine, asparagine, aspartic acid, cysteine, glutamic acid, glutamine, glycine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, proline, serine, threonine, tryptophan, tyrosine, valine. [1]

The application presented in this paper supports the learning of the 20 amino acids in an interactive way not only by displaying them in a 3D space, but also by using

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some recognized gestures implemented for the Leap Motion sensor. With this application the users can combine freely any nucleotide from the DNA to obtain an amino acid. The main condition for using this kind of application is that the user should poses a Leap Motion sensor, such a device being not very expensive. Using the application, the students will learn very fast the gestures used for DNA bases control.

The literature study shows some applications using the Leap Motion sensor to control the 3D images of different molecules (lithium, sodium, potassium, rubidium, cesium) to study the reaction that these molecules have with water (as in ChemGrabLab application). [2] The disadvantage of this application is that the gravitation effect overlaid on the 5 3D images of the mentioned molecules is not very well calibrated. Touching the molecules with the virtual hand offered by the Leap Motion package, these tend to flow or many times take a strange trajectory in the 3D virtual space. Another application, ChemEx 3D [3], offers to users the possibility of learning molecules from Mendeleev`s table. The Molecules [4] application allows the control by using gestures in the 3D space of different molecules. In the specialty literature, the Leap Motion sensor is used alongside with Arduino microcontrollers for turning on/off the bulbs from a room [5] with the aid of some gestures implemented for this sensor.

Another device used in gesture recognition is Microsoft Kinect [6], a device used in some studies in checking the correct sitting posture in front of the computer of users of specific ages. The results of this study consist in identifying incorrect user postures when working with a computer. [7]

Combining cutting edge technologies based on gestures with genetic code elements resulting in development of a 3D application supporting the user in visualizing the 3 DNA bases is the main goal pursued in our work and in this paper.

The main motivation of presenting the results of our work is to offer the medicine, chemistry or bioinformatics students, or the human genetics domain passionate people a new way of learning the amino acids by gesture, controlling the nucleotides and the 3D visualization of the application.

In this paper we emphasize the importance of using gestures in control of applications, and displaying it in 3D. The final result is that users can view, control, and learn more quickly and in a familiar environment the amino acids than in the classic way.

2. Methods and tools

The novelty of the *AminoMotion* application compared to other studied applications from the specialty literature is using the Leap Motion sensor by creating new gestures in the application control and the development of a new algorithm based on each amino acid corresponding tag depending on the 3D virtual space position of the 4 DNA nucleotides and their type for learning the amino acids.

The proposed application is a desktop application and based on Unity 5.6 editor and on Leap Motion sensor, a sensor which can recognize the hand gestures. The development language is C# for both, the development process of the Leap Motion recognized gestures and for the nucleotides tagging algorithm to compos the amino acids. We use the Hand Controller [8] script from the Leap Motion Unity SDK (Software Development Kit).

2.1 Unity

Unity is common in the game industry, mostly because of the depth and the quality of its optimizations, but also for its speed and efficiency of its workflow, offering Unity users the possibility of developing high quality content in a very short time. Using Unity the editor the user has the possibility to create content not only for 2D projects but also for 3D ones.

Among other features, Unity offers integration with the stand-alone Visual Studio C# editor. This integration offers the possibility of automatic creation and maintenance of Visual Studio project files. [9]

2.2 Leap Motion

Leap Motion can distinguish between human gestures (swipe, circle, screen tap and key tap), to support interaction with the virtual environment and augmented reality without touch. This sensor allows the creation of new gestures, not just using the 4 predefined ones from its software system. Creating new gestures for the Leap Motion sensor is possible due to its capacity to recognize each finger from a hand and make the difference between the left hand and the right one. [10]

For this complex application of amino acids creation development, in the Unity editor we used 3D objects. All of these 3D objects, have been set on specific positions and dimensions for user interaction in the 3D virtual space.

On the interaction table are present 4 types of nucleotides (A, C, G, U), each of them having a different color, green for the adenine, red for the cytosine, blue for the guanine and yellow for the uracil/thymine (Figure 1.). Each nucleotide having 3 samples for assuring that the user has the possibility to obtain any of the 20 amino acids. One of the important features of the application is that on the 3D objects representing a nucleotide type we applied a gravitational effect. In Unity editor this gravitational effect it is named *Rigidbody*. The 3D objects are defined as cubes, because it was noticed that after applying the gravitational effect these cubes are behaving better than the 3D spheres used at the begging of application development. All the cubes used in the application have the *Finish* flag enabled for making it easier to recognize them when they are catch with the predefined catching gesture.

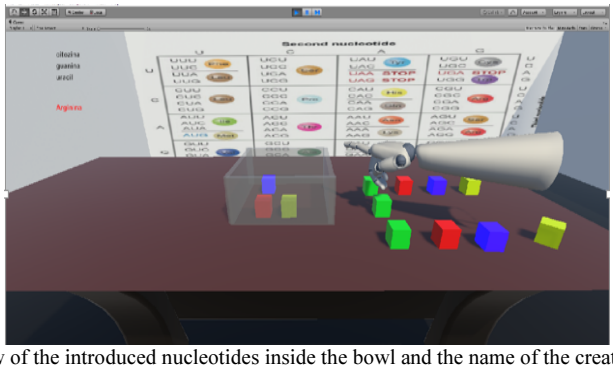

Figure 1. View of the introduced nucleotides inside the bowl and the name of the created amino acid

Sticking Gesture is an original gesture defined for this application. The functionality of this gesture is given by the Leap Motion sensor capacity of recognizing

the hand fingers. Thus it was used the index finger of the right hand. For sticking a nucleotide to the right hand index finger, the finger has to be positioned at a 0.3 units distance from the object. Inside this gesture, in the C# script it is performed a search for the finger in the right hand fingers list and when this is found (the Leap motion sensor detects it) and its position is at a smaller distance than 0.3 units, than the 3D object gets stick to the index finger.

For catching the 3D object (the applying of sticking effect on the hands index finger of a 3D object) it has been defined the following inequality:

$$\sqrt{[(x_2 - x_1)^2 + (z_2 - z_1)^2]} \leq 0.3 \quad (1)$$

Where: (x_1, z_1) – represents the 3D objects coordinates

(x_2, z_2) – represents the coordinates of the hands index finger

After sticking the 3D object (nucleotide) to the finger the user can move it wherever wants inside the virtual space. For moving the 3D object inside the nucleotides combination bowl, the user has to be positioned with the stick object to the virtual hands finger above it. When the object is above the bowl, the sticking effect of the index finger will disappear, and the 3D object will fall inside the vase, because of the gravitational effect applied on it. Each nucleotide selected by the user with the aid of this gesture will result with the displaying of the selected nucleotide's name on the screen. The corresponding C# script of this functionality it has been added on top of *Hand Controller* object.

The *Amino acids algorithm* is defining the name of the amino acids created in the 3D interaction bowl (Figure 1) by combining 3 nucleotides. It takes into account the name and the position (order) of the nucleotides. At the beginning, are read the nucleotides with the *Finish* tag, then the position is initialized with zero and the nucleotide variable with null. If the position is different than 3, the nucleotide will take one of the following values: A, C, G, U and the position will be equal to 1 and this process will be repeated until the position will be equal with 3. When the position will be equal with 3 the name of the formed by combination of 3 nucleotides amino acid will be determined.

3. Results and discussions

The inequality (1) represents the distance between two points, between the 3D object coordinates and the hands index finger coordinates. Even if this coordinates are from the 3D space (x, y, z), it was given up the calculations between the two points and for the y coordinate, which represents the height, for reasons of application answer speed to gesture. Thus it is calculated the distance between the two points only on x and z coordinates which represents the thickness and width in the 3D space.

Cubes are the basis to form the 3D images representing the 4 types of nucleotides. In our work, initially we used spheres, but when they have the gravitation effect applied they were rolling and eventually fall of the table, being hard to control.

The developed application offers to users a familiar type of interaction with the laptop/computer, using gesture interaction. This supports the training of students learning the 20 amino acids formed by combining three nucleotides. The users have the possibility to combine freely any kind of nucleotide and they receive as an answer the name of the created amino acid.

The 3D environment provided by the application, the amino acid name association algorithm and the gesture interaction are the main contributions of our work and presented in this paper.

To evaluate the usability of the application we tested it to calibrate the coordinates of the index finger and the 3D cube, and we refined the application until the result was the best. Using 3D cubes in the representation of the nucleotide at the expense of spheres helps a lot in catching the object with the gesture associated with the Leap Motion device. The *AminoMotion* application is a new and original application using the Leap Motion sensor for studying human genetics. The testing lot consisted in 27 medical students and 23 chemistry students. The usability study results will be published in the future.

The application test focuses on the impact on the students, how easily they interact using Leap Motion gestures and the ease of learning the amino acids. At the same time, a comparison between the use of 3D and the classic 2D display and outocmes learning of amino acids is planned for near future.

For a better interaction in the future we will implement a gesture that can catch/stick more than one nucleotide at a time. For the future the application will be ready for mobile support.

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