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ScienceDirect

Procedia Computer Science 75 (2015) 103 – 106

Procedia Computer Science

2015 International Conference on Virtual and Augmented Reality in Education

# Kinect-assisted Visualization of Functions of Two Real Variables in Mathematics

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**Abstract**

This paper will review the creation of a physical structure with technological components that will allow the student to visualize changes in depth on a real surface in a continuous manner. Using a Kinect for Windows and a projector, it is intended to create a didactic environment involving visual and gestural aspects, aiming for a better comprehension about plots of functions of two real variables as surfaces in space. Colored imagery is projected onto an elastic cloth where the student can create peaks and valleys, allowing them to perceive the relation between colors and depth changes in the surface.

Peer-review under responsibility of organizing committee of the 2015 International Conference on Virtual and Augmented Reality in Education (VARE 2015)

*Keywords:* Kinect; Visualization; Mathematics; Projection.

## 1. Introduction

Interaction between the student and the technological environment can be broadly classified as discrete or continuous, depending on the reciprocal action and navigation of the concepts represented via static images or, on the other hand, as dynamic, constructible and deformable objects [1].

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doi:10.1016/j.procs.2015.12.225

In a continuous scenario, mathematical constructions that are usually abstract in nature, become more dynamic –like motion-based events– where explorations and reasoning are based around the aggregation of mathematical objects and are furthered by the interaction between the student and the environment [2].

This process, where both the student and the medium re-act to each other is what Moreno-Armella and Hegedus call co-action, and it can only occur if a border object –a mathematical object accessible in a way so that it is able to be meaningfully explored by the student– is present [2].

Border objects point towards mathematical content not that explored yet [3], and thus represent an innovative tool to deliver certain mathematical content in a more visual and executable manner, providing situated proofs within the same technological environment [4].

It is our intent to achieve a better understanding of contour lines (like those shown in Fig. 1) by creating a visual setting where students can recognize them on a physical, modifiable surface in space, in real time.

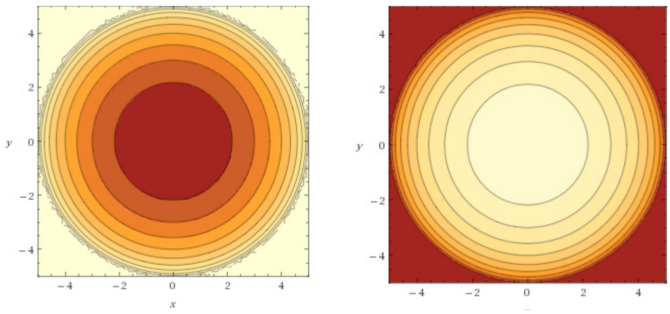


Fig. 1. Contour lines of a sphere.

### 1.1. Kinect for Windows

The Kinect for Windows motion sensing input device, which second version was made available during mid July 2014, enables users to control and interact with a computer via gestures and spoken commands. It is equipped with an infrared (IR) depth sensing camera which will be used for this project. Its specs can be found in Table 1.

Table 1. Kinect Specifications.

| Feature | Specification |
|---|---|
| Depth camera resolution | 512 x 424 px |
| Max depth distance | ~4.5 meters |
| Min depth distance | ~50 centimeters |
| Horizontal field of view | 70° |
| Vertical field of view | 60° |
| USB Standard | 3.0 |

## 2. Development

Kinect's depth-sensing can get the distance between the Kinect sensor and the environment at a rate of 30 frames per second. This depth information is then used to color each pixel of the environment matrix according to the color wheel and depending on how far each point is. Closer points will be colored with warmer tones, and cooler tones will be assigned to farther ones. Fig. 2 shows this behavior.

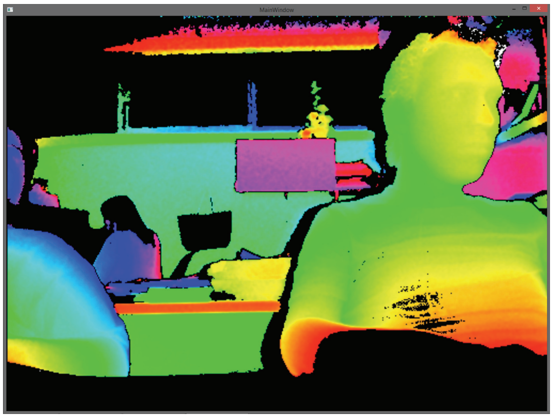

Fig. 2. Kinect's depth sensing and coloring of the screen.

The coloring data needs to be transformed from HSV to RGB in order for the pixels to be recolored properly. After the coloring is done, the resulting image is appended to the Graphical User Interface (GUI) which is being created using C# Windows Presentation Foundation (WPF) format. The GUI consists of a simple grid on top of the image created before. Fig. 3 shows the GUI.

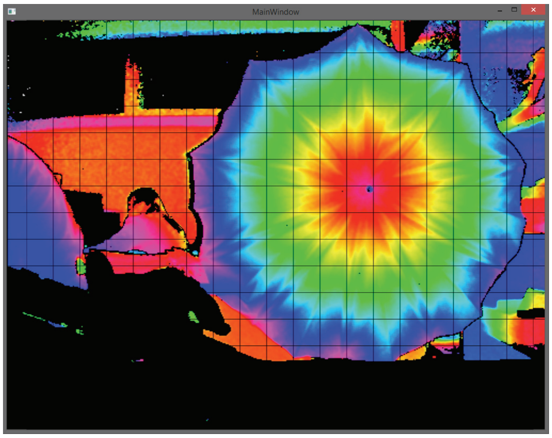

Fig. 3. Grid on top of the colored image.

All the data handling is being made using Kinect for Windows SDK 2.0, available for free on Microsoft Download Center. Treatment of depth data has been developed already, but the physical structure for the projection has yet to be constructed.

## 3. Conclusions and future work

In this short paper, we focused on the development of the projection, showing the project's progress at the moment and discussing about the desirable final product we look for.

The construction of the prototype is the next step to consider. The prototype should contain a modifiable surface, an elastic piece of fabric (or other material) where the student can interact pulling or pushing the surface around. This interaction generates a cognitive relation between a student's action and its observable representation, fostering the comprehension of abstract concepts, like peaks and valleys found on plots of functions of two real variables displayed as surfaces in space.

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