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A gameified application to represent hand-drawn level curves in augmented reality

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ABSTRACT

We present a mobile application designed to enhance students' understanding of directional derivatives and level curves in first year's calculus. The application offers visual tools and gamified learning to provide an engaging educational experience. Using novel technologies such the application is able to take a users drawing, generate a corresponding 3D model, and display this to the user. Through this presentation, attendees will gain a comprehensive understanding of the application's features and the benefits it offers to students in comprehending directional derivatives.

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1 INTRODUCTION

The presented application is called LavaFlow and is hosted at https://lava.ewi.tudelft.nl/. Given level curves drawn by a user, it is able to scan these and convert them to a 3D model of a mountain. As a game, users have to predict the direction of a flow of lava along the slopes of the generated mountain, earning more points for more accurate predictions. This application is to be used in first-year's calculus courses, with the goal of giving a student a better intuition for the relationship between level curves and directional derivatives.

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2 CORE FEATURES

This section highlights the most important pages of the application, giving a detailed overview of what the application has to offer. Each page description is accompanied by one or more screenshots.

2.1 Image capturing

The image capture page within LavaFlow enables users to capture an image of their hand-drawn level curves. The intention of this step is to facilitate collaboration between students as the same-level curve drawing can be scanned by different devices. Users are provided with options to review and retake the captured image if necessary.

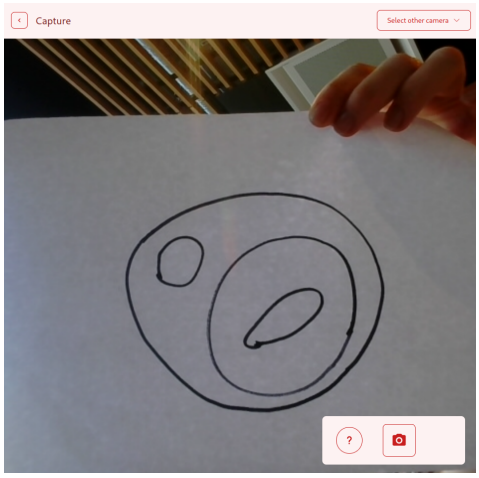

Figure 1: Capturing an image of hand-drawn level curves.

2.2 Isolating the level curves

The drawing isolation page in LavaFlow allows users to isolate the drawn level curves from the background of their image. The image captured on the previous page is processed to emphasise drawn lines and shown to the user. The user must then drag the corners of a box around their drawing for it to be processed correctly, a

selection cannot contain excessive noise or incomplete level curves or a model cannot be generated.

Figure 2: Isolating the level curves in the captured image, with the help of a preview in the top-right corner of the GUI.

2.3 Model preview and AR

The 3D model viewing page in LavaFlow allows users to explore the generated mountain model before being asked to place steam turbines. To make this step more engaging, a regular and an augmented reality (AR) view are implemented, which uses the user's camera to project the generated model onto a surface in front of them. In both viewing modes, users can interactively rotate, zoom, pan, and analyze the model from various angles, facilitating a thorough examination of its topography and surface features.

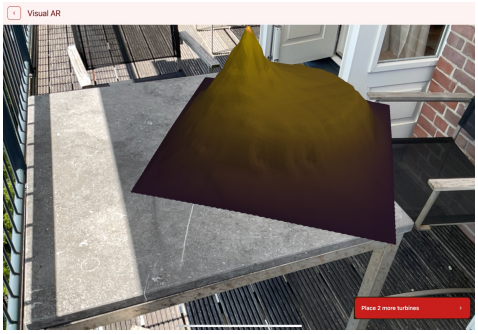

Figure 3: The model generated from the default level curves, without lava in AR.

2.4 Steam turbine placement

The turbine placement page in Lavaflow engages users in the process of predicting the direction of the lava flow along the slopes of the generated mountain model. A user is asked to place two or more steam turbines in positions they expect lava to flow. The source of the lava (the crater) is the point with the highest altitude on the model, which is shown to the user along with the processed level curves. Steam turbines can be placed clicking a desired position, and be removed by clicking the same position again. Up to 10 steam turbines can be placed.

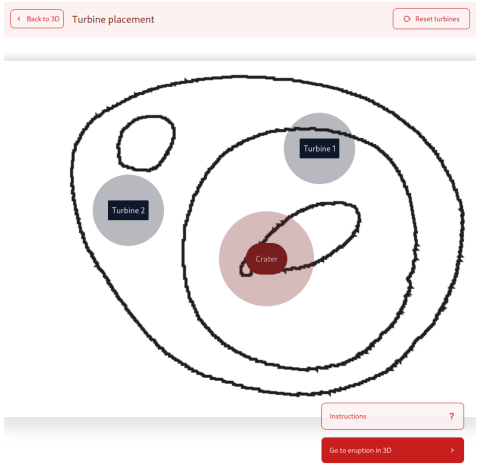

Figure 4: Placing turbines on the level curves.

2.5 Generating Lava and earning points

Once the turbines have been placed, one can return to the model preview and start the lava eruption. The lava is generated from the crater, and takes the steepest route down the mountain, dividing where gradients in different directions are similar. If a user has been accurate in their prediction, their steam turbines will be activated by the lava and they can expect a high score. Else they can try again by going back to the turbine placement page and changing the positions of the steam turbines.

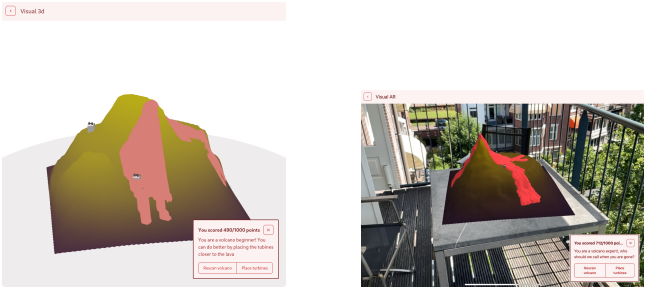

Figure 5: The model with user-placed turbines and lava. The amount of points a user has scored is shown in the bottom right.