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Feature-based terrain editing from complex sketches

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ABSTRACT

We present a new method for first person sketch-based editing of terrain models. As in usual artistic pictures, the input sketch depicts complex silhouettes with cusps and T-junctions, which typically correspond to non-planar curves in 3D. After analysing depth constraints in the sketch based on perceptual cues, our method best matches the sketched silhouettes with silhouettes or ridges of the input terrain. A deformation algorithm is then applied to the terrain, enabling it to exactly match the sketch from the given perspective view, while insuring that none of the user-defined silhouettes is hidden by another part of the terrain. We extend this sketch-based terrain editing framework to handle a collection of multi-view sketches. As our results show, this method enables users to easily personalize an existing terrain, while preserving its plausibility and style.

1. Introduction

Terrain is a key element in any outdoor environment. Applications of virtual terrain modelling are very common in movies, video games, advertisement and simulation frameworks such as flight simulators. Two of the most popular terrain modelling methods are procedural [1–4] and physics-based techniques [4–9]. The former are easy to implement and fast to compute, while the latter produce terrains with erosion effects and geologically sound features. However, the lack of controllability in these methods is a limitation for artists.

Sketch-based or example-based terrains have been popular recently in addressing these issues [10–16]. However, many of these methods [12,14,16] assume that the user sketch is drawn from a top view, which makes shape control from a viewpoint of interest difficult. Others [10,11,13,15] only handle a restricted category of mountains, with flat silhouettes. Lastly, terrains fully generated from sketches typically lack details. Dos Passos et al. [17] recently presented a promising approach where example-based terrain modelling and a first person point-of-view sketch are combined. However their method does not support local terrain editing and cannot handle typical terrain silhouettes with T-junctions. Moreover, terrain patches are often repeated which may spoil the plausibility of the results from other viewpoints.

In this work, we address the problem of intuitive shape control of a terrain from a first person viewpoint, while generating detailed output that is plausible from any viewpoint. To achieve the intuitive shape control goal, we stick to the sketch-based approach, but allow the user to input complex silhouettes, as those are typically used to represent terrains (see Fig. 1). Our interpretation of the term "complex" is similar to the one used in SmoothSketch [18], where a complex sketch is a set of 2D strokes with hidden contours and cusps. To get plausible, detailed results from any viewpoint, we focus on editing an existing terrain rather than starting from scratch. This approach captures the coherent small details from the existing terrain, while avoiding the patch blending and repetition problems that are typical of example-based methods. The use of an existing terrain also enables matches of sketched silhouettes with plausible, non-planar curves on the terrain.

In practice, the user edits the input terrain by over-sketching it from a first person viewpoint. The user strokes, forming a graph of curves with T-junctions, represent the desired silhouettes for the terrain. The input terrain is then deformed such that its silhouettes exactly match the strokes in the current perspective view. This means that each stroke segment is to be some silhouette of the output terrain, and that no other part of the deformed terrain should hide them. Previous sketch-based modelling methods have successfully used feature curves to deform surfaces [19,20]. Our work explores the use of terrain features for sketch-based terrain editing.

Paper contributions: This paper is an extended version of earlier work [21] in which we first introduced a framework for deforming

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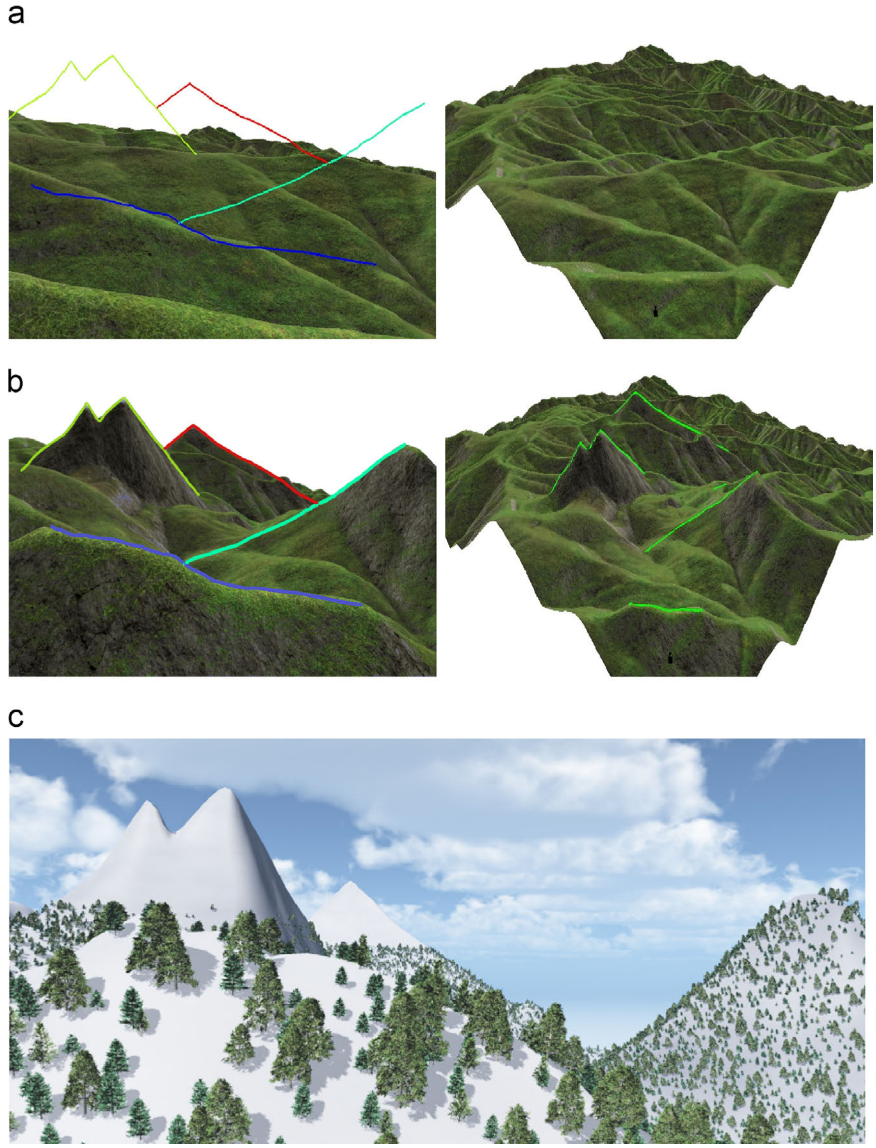

Fig. 1. (a) An artist sketch (left) is used to edit an existing terrain (right). (b) Results shown from two viewpoints. Note the complex silhouettes with T-junctions, matched to features of the input terrain. (c) A rendering of the resulting terrain from a closer viewpoint is shown.

terrain features to fit user strokes. First, sketched strokes are ordered by inferring their relative depth from the height of their end-points and from the T-junctions detected in the sketch. Next, features of the input terrain such as silhouette edges and ridges are assigned to each stroke and extended if necessary, to cover the length of the stroke. This assignment is the solution of a minimization problem expressing the similarity between a terrain feature and a stroke in the drawing plane, and the amount of deformation caused by their matching. The selected features then become constraints for an iterative diffusion-based terrain deformation method. The main contributions of that earlier paper [21] are the following:

- An algorithm for ordering strokes in a complex, perspective sketch with respect to their distance from the camera.
- A method for matching terrain features with user-specified silhouettes, drawn from a given first-person viewpoint.
- A deformation method for matching silhouette constraints while preventing them from being hidden by other parts of the terrain.

This paper provides an in-depth discussion of the branch-and-bound search scheme used to address the energy minimization problem. Additionally, we propose an improved framework that supports terrain editing from multi-view sketches drawn from different viewpoints. In the context of film making, this additional tool can facilitate control of the exact shape of terrain silhouettes for two or three views, which will be used for key scenes. Although iteratively editing the terrain from multiple viewpoints could achieve realistic landscapes, there is no guarantee that silhouettes generated during one iteration will not be significantly modified by subsequent iterations. The stroke-to-feature matching algorithm is modified to handle all sketches at once, with additional constraints that ensure that no assigned feature is occluded by another. Finally, we claimed in the original paper that specifically deforming terrain features produces more realistic results. To illustrate this, we compare the use of feature-based curve constraints in terrain deformation against using 3D planar curve constraints obtained from projecting strokes on the drawing plane. We show how the two types of constraints affect terrain deformation and realism on 3 different test cases.