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Realistic Texture Synthesis for Point-based Fruitage Phenotype

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Abstract

Although current 3D scanner technology can acquire textural images from a point model, visible seams in the image, inconvenient data acquisition and occupancy of a large space during use are points of concern for outdoor fruit models. In this paper, an SPSDW (simplification and perception based subdivision followed by down-sampling weighted average) method is proposed to balance memory usage and texture synthesis quality using a crop fruit, such as apples, as a research subject for a point-based fruit model. First, the quadtree method is improved to make splitting more efficient, and a reasonable texton descriptor is defined to promote query efficiency. Then, the color perception feature is extracted from the image for all pixels. Next, an advanced sub-division scheme and down-sampling strategy are designed to optimize memory space. Finally, a weighted oversampling method is proposed for high-quality texture mixing. This experiment demonstrates that the SPSDW method preserves the mixed texture more realistically and smoothly and preserves color memory up to 94%, 84.7% and 85.7% better than the two-dimesional processing, truncating scalar quantitative and color vision model methods, respectively.

Keywords — Fruitage morphology, Texton division, Texture synthesis, Texture sampling

1 INTRODUCTION

Current fruit modeling, realistic rendering and fruit quality analysis depend primarily on photorealistic 2D images [1,2], forward modeling methods [3-5] and triangular mesh-based methods [6]. However, these methods only consider VFX, and the neglected realistic appearance and texture of various fruits consume large amounts of CPU time and storage and require rendering distortion when applied to a high-precision fruit to cope with the anamorphose caused by color, resolution, accuracy, pose, coverage, lighting, scaling and background [7,8]. Therefore, these methods cannot satisfy the higher continuity requirements, and accurately reproduce the texture morphology of complex crop fruits.

1.1 Motivation

With the development of agricultural informatization and electronic farming, the real appearance traits of apple organs and fruit surfaces, such as smoothness, color and authenticity, play an ever more important role in disease classification, growth stage representations, product prestige improvements, fruit rank promotion, and product display [1,2,9,10].

In contrast to the aforementioned methods, with the development and improvement of 3D scanning precision [11,12], point-based modeling has made it possible to acquire the cloud points of apple fruits with rich details and high density [13-16]. Furthermore, because of the non-topologic connection among points, the method can present the morphology of apple organs with rich details more flexibly and veritably than other methods.

However, real preharvest apples, usually growing in field trees with a scattering background, pose a challenge for the acquisition of both the points and image at the same time, which causes the fruit images to be separated from the scan and results in large amounts of redundant image information. Moreover, a high-precision scanner is employed to capture the rich details of the fruits, resulting in high complexity for numerous point clouds, which can be time consuming to process on a standard computer. To process these data effectively, the point clouds are typically simplified into small units in advance [17-19], which can result in seams, gaps or overlap between simplified primitives.

Therefore, it is important to increase the realistic nature of the visualization, improve the efficiency of texture organization on point clouds and achieve a better trade-off between texture storage performance and visual effects in primitive-based fruit texture synthesis. In this paper, we provide accurate color phenotype information for agronomy researchers in the context of different traits of apple textures and a precise analysis for studying biology regulation of apple color development; we also provide reliable data for researching apple diseases from a 3D perspective.

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