基於影像曲面上之高曲率特徵點之影像表示法

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中文摘要

在本篇論文中我們發展了一套影像之表示法。在物理上，若使用三維管線將一張彈性布撐起與擠壓，可產生不同的幾何曲面型態。基於這個想法，我們把原始影像視為影像曲面，然後使用微分幾何的觀念來找出高曲率點，並以這些高曲率點為基本元素來表示整張影像。我們認為，這些高曲率點擷取了影像中的重要特徵，所以可以很容易地重建回影像曲面；此外，使用高曲率點影像表示法可以改善原始的影像表示法(陣列元素表示法)的缺點，進而達到精簡的資料量、有效率的特徵擷取、彈性的影像內容操控這三大特色。

為了得到合適的高曲率點，在本論文中我們針對高曲率運算元之選擇，與曲率門檻值的選擇加以理論分析與探討。為了更有效的表示整張影像，性質相近的

高曲率點可連結成高曲率曲線，高曲率曲線又可以三維B-spline控制點加以近似，以增加此表示法之彈性與多樣性。

為了使高曲率點表示法能以精簡的方式記錄高曲率點，我們設計了階層式的資料結構以表示影像曲面之組態，並以此資料結構為基礎，發展一套影像壓縮系統，針對此壓縮系統選擇合適的量化器與編碼方式，實驗結果顯示，所提出的影像壓縮法可達成與JPEG系統相近的視覺壓縮品質。此外，利用所提出的影像表示法，可以達成影像可調性與影像互動性；在所提出的架構中，影像可調性包括訊號雜訊比可調性、空間可調性、與形狀可調性；至於影像互動性方面，可作"Region of Interest"傳輸，並可使接收端的使用者方便的調整解碼之影像，由於具有影像可調性與影像互動性，使得本表示法可適合於網路系統的傳輸。

在這篇論文中，我們直接利用高曲率點表示法所記錄的資訊來偵測影像中的基本元素，像是點、線、轉角等影像基本元素。對於這些特徵，除了偵測位置之外，利用高曲率點表示法也同時偵測了其他參數，像邊界寬度與對比等。我們利用Hessian張量所求出之一對特徵值與特徵向量來偵測曲面之特性，利用這些特性，如 符號：Concave 或是 Convex，或是型態：Elliptic、Parabolic、以及Hyperbolic曲面型態來分類與偵測影像中的基本元素，由於所提之方法是以成對的方式紀錄了這些基本元素，因此可利用成對的資訊來作對比調整或是特徵區分。為了驗證所提方法的可行性，我們與線偵測運算元Canny Operator與轉角偵測運算元Harris Operator作比較。此外，我們亦提出了一個Multi-scale的架構來偵測切割影像曲面中的平坦區域。

為了驗證高曲率點表示法對影像內容操控上的彈性，在這篇論文中，基於高曲率點影像表示法，我們發展一個彈性的架構來進行影像編輯。因我們將影像視為一張彈性布被三維管線撐起與擠壓，若沿著X-Y平面或是Color Axis改變這些管線，影像曲面也會隨之改變。因此，所提出的影像表示法相當適合於影像特徵加強與編輯。為了達成影像編輯的目的，我們將原影像拆解成主幹分量與剩餘分量；主幹分量可由高曲率點以迭代線性內插的方式所產生，而剩餘分量則是原影像與主幹分量之差值。藉由調整主幹分量可改變影像中的重要輪廓，藉由調整剩餘分量可改變影像中平坦區域的粗糙與平滑程度。因此，利用所提出的拆解方式，可對原影像作區域或是全域的影像增強或平緩，亦可利用B-spline控制點來改變物體的形狀或是新增、刪除物件，以達到物件特徵編輯的目的。

Representing Images Using Verge Points on Image Surfaces

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Abstract

In this thesis, we propose an approach to represent images. The proposed representation scheme is inspired by the concept of emulating an image surface with a rubber cloth stretched by 3-D pipes. The whole procedure is developed with the aid of differential geometry to extract verge points from image surfaces. The proposed verge point representation may provide three types of improvement over the raw data representation scheme. They are compact data size, efficient feature detection, and flexible image content manipulation.

In this thesis, we develop a few compact, hierarchical data structures to store verge points. The extracted verge points with compatible properties are linked into verge curves. These extracted verge points offer an effective way to extract spatial features, like edges, of the original image. In addition, the extracted verge curves can be further compressed using B-spline approximation. Based on the extracted verge curves or the

computed B-spline control vertices, a scalable, interactive image codec and a flexible image editing architecture are proposed.

In designing a feature-based method for scalable, interactive image compression, the features in an image can be revealed at the decoder side by transmitting the B-spline control points. We construct a hierarchical data structure to encode these control points. The visual performance of the proposed method is comparable to that of JPEG using the proposed data structure. The control points can be rearranged to support diversified scalabilities, such as SNR scalability, spatial scalability, and shape scalability. The proposed method is suitable for "region of interest" selection and transmission. Experimental results are provided to demonstrate the scalability and interactivity of the proposed image codec.

In this thesis, we develop an efficient mechanism to detect image features directly from extracted verge points. In addition to feature positions, other related parameters, such as span and contrast, can also be efficiently detected based on verge points. To detect essential elements on image surfaces, the Hessian operator is used to find points, edges, and corners. We use the characteristics of image surface, identified by principal curvatures, to find these feature elements. For an edge, we detect the edge center, edge contrast, and edge span using verge pairs. The profile of an edge can be approximately reconstructed using these three elements. Meanwhile, the detected edge contrast and edge span can be adjusted for different purposes, such as contrast enhancement and sharpness enhancement. The Hessian tensor can also be used to find corners, which are useful for feature selection and edge linking. Experimental results have shown that the proposed operator is comparable to Canny operator in detecting edges, and comparable to Harris operator in detecting corners. In addition, we demonstrate the feasibility of using a multi-scale scheme to perform region segmentation.

In this thesis, to demonstrate the flexibility of the proposed verge point representation, we develop a flexible framework for image editing. An original image is decomposed into a skeleton component and a residual component. By manipulating the skeleton component and residual component, different visual effects in contrast adjustment and sharpness enhancement can be achieved. With the aid of the skeleton curves, we can achieve adaptive feature editing, which is a difficult task if using conventional methods such as histogram equalization or unsharp masking. By changing the position of the control points used to approximate verge curves, the shapes of objects in an image can be modified. Experimental results have demonstrated the versatility and flexibility of the proposed scheme.