Multi-view Wire Art背景研究 01

Rapid Octree Construction from Image Sequences

從圖片序列快速生成八元樹

Richard Szeliski

1993

論文引用

- “Assuming clean foreground-background separation, visual hull and silhouette intersection based algorithms can be also applied to construct 3D models from image observations [Laurentini 1994; Lazebnik et al. 2007; Matusik etal.2000; Szeliski 1993]…”

  (page2, “2.Related Work”)

- Richard zeliski.1993. Rapid octree construction from image sequences. CVGIP: Image understanding 58,1(1993),23–32.

  (page11, “References”)

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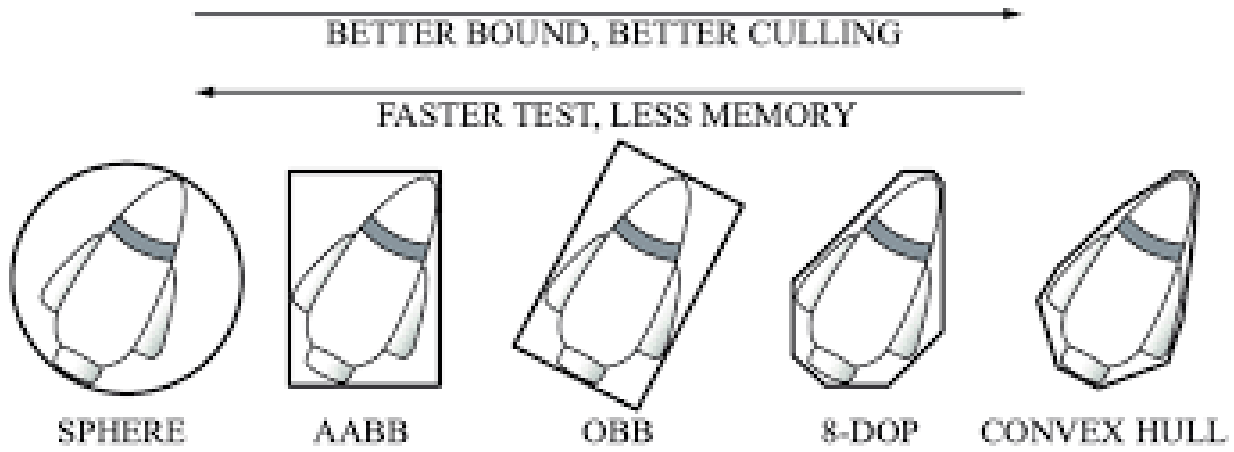
CV重要問題：如何利用多角度照片生成物體的3D模型
較簡單的解決方法之一：利用物體的輪廓創建該物體的包圍體（如圖）



通常會使用Octree（八元樹）結構來表現3D物體的包圍體，即將物體比作一棵樹，生成的樹枝再不斷將該物體層層分解成大小遞減的正方體。
本文介紹了一種新的演算法，從物體多角度的輪廓圖片中計算目標物體的八元數，對多角度圖片進行有限的處理來逐漸生成出一個有體積的3D物體。

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實際應用時，將目標物體放在一個轉盤上，并在固定位置架設相機來收集多角度照片。

兩個目標:

- 照片輸入同時進行計算
- 在更多照片輸入的同時逐漸優化外形

（尋找高度同步的演算法，一個物體只生成一個八元樹圖）

邊拍攝多角度圖片邊處理新的圖片，將初始八元樹圖不斷細化，每次輸入新的圖片都只生成一個模糊的形狀，減少計算量。

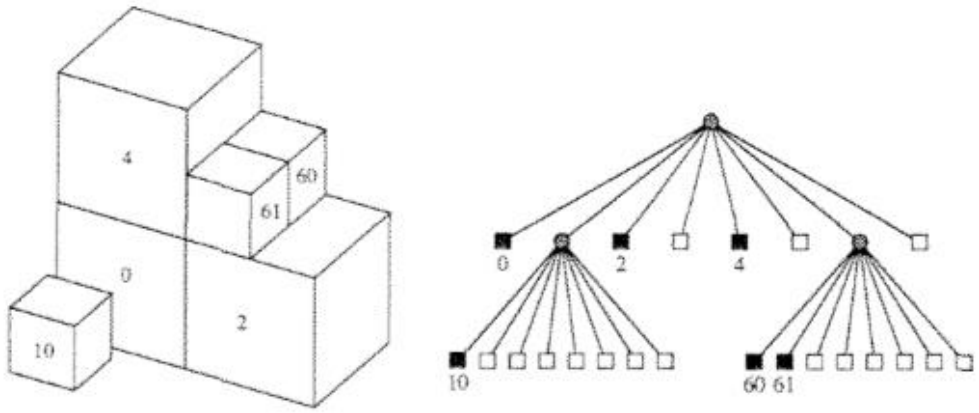

FIG. 1. A simple two-level octree and its tree representation

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2. 八元樹圖簡介:

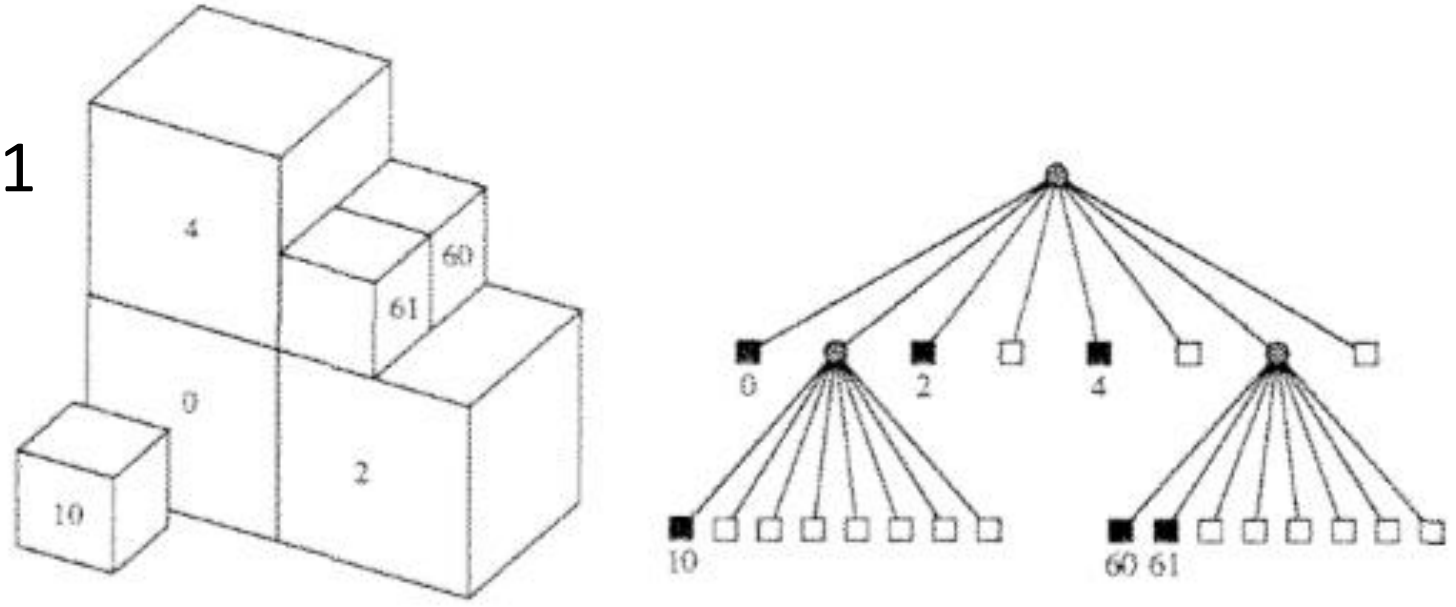
利用一個單元正方體，描述某個物體體積和外形數據的樹形圖。

每個正方體都被分成8個更小的正方體，所有的正方體有三種可能的顏色（黑，白，灰）分別按照體積劃分為:

黑=1

白=0

0<灰<1



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3.演算法分級生成樹圖過程概述

建構一個模糊到精確的分級過程

3D物體與照片中的物體輪廓進行比對，從而逐漸生成有更多細節的模型。

- 初始設定：默認轉盤上的物體為8*8*8的黑色正方體
- 辨識輸入圖片（辨識結果如下）：

黑色的正方體認定爲物體内部

白色正方體為物體外部（不屬於物體本身）

灰色正方體為部分在外部分在内（需要後續進一步分級）

-電腦不停地將已生成的模糊的物體形狀投射在輸入的照片上，與輪廓進行比對，優化邊緣和物體内部不準確的正方體顏色

優化槩則：黑色可以變爲灰/白，灰色可變爲白。白色不能改變（視作被切除的部分）。

-最終，經過完整的計算處理過程，對灰色的部分進行進一步的分級（分成八個等大的正方體），直至確定新分出的方塊為黑色或者白色

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4. 圖片輪廓交叉測試

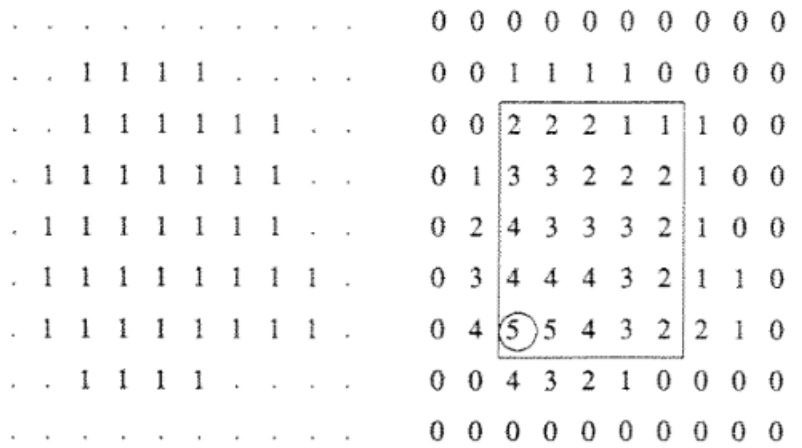

FIG. 2. The half-distance transform and its use in inclusion testing. A sample binary image is shown on the left, and its half-distance transform is on the right. The circled 5 in the distance map indicates that a 5×5 square is the largest square inside the silhouette whose lower left corner is at that pixel.

左圖為相機拍下照片的二元圖像:
數字1為檢測到物體的部分
右圖為該圖像的距離變換:
被圈出的數字5代表該位置有一個5*5的正方體，是被檢測到的輪廓內最大的正方體（最靠近相機），位於輪廓的左下角。

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5.演算法在數位幾何體上的測試結果

爲了測試演算法的實用性，用電腦生成的超二次曲面體進行模擬測試（幾何體渲染與實物測試時的相機位置和轉盤角度一致），整個模擬過程與實物測試一致，輸入照片和演算法計算分析同時進行（有限的視角照片輸入與相機位置造成了一些凹陷和頂部突起）

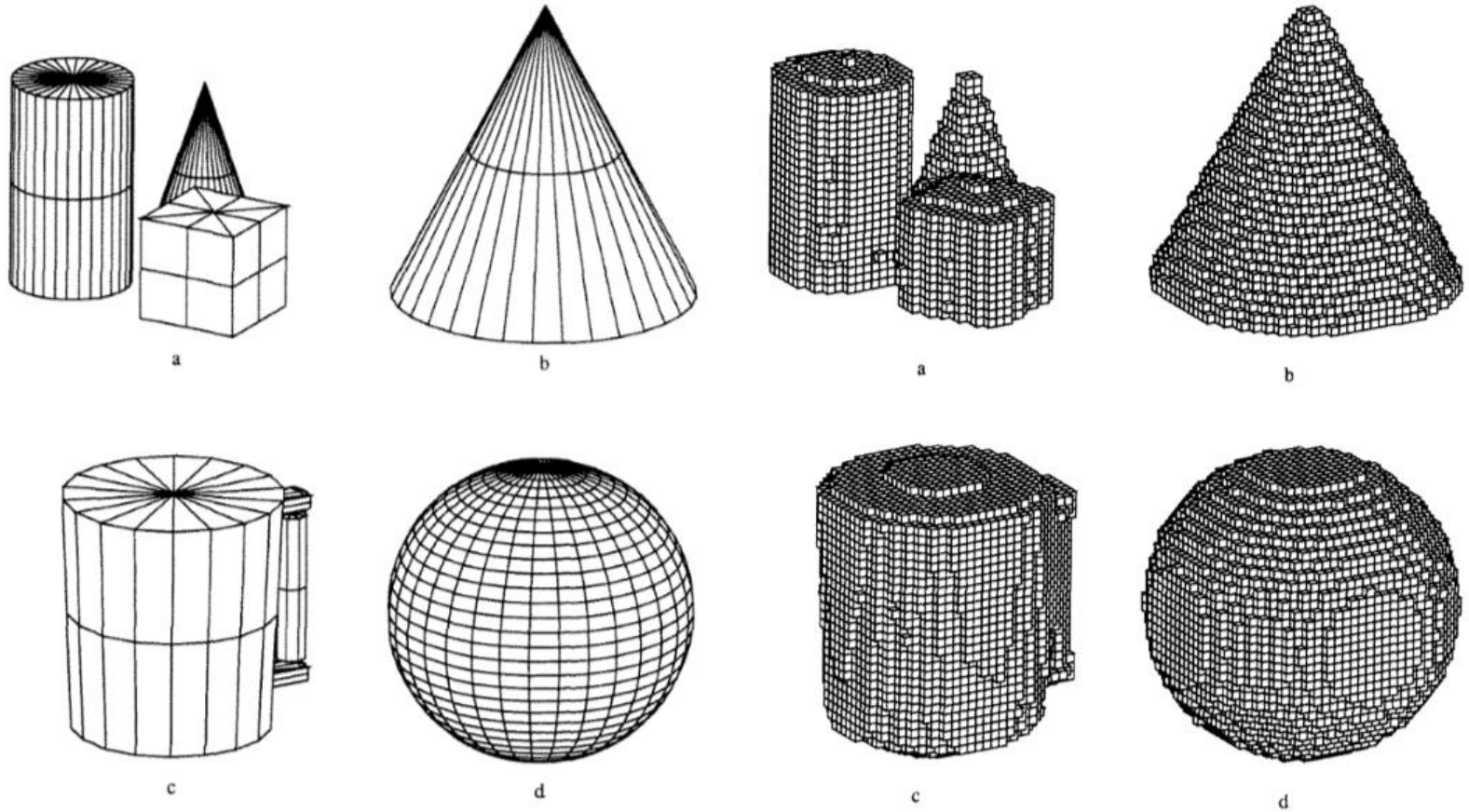

FIG. 3. Superquadric test models: (a) blocks, (b) cone, (c) cup, (d) sphere.

FIG. 4. Derived octree models: (a) blocks, (b) cone, (c) cup, (d) sphere.

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6.演算法複雜性分析 Octree Construction Algorithms

幾種分級八元樹演算法與傳統八元樹演算法進行比較:

1. 分級式生成算法（整個過程僅生成一個八元樹圖），只計算明確體積的正方體（黑/白））

2.分級式生成算法，計算所有正方體直至全部正方體的體積都明確

3.分級式生成算法，只計算上一級辨識結果為灰色（體積不明確）的正方體

4.傳統八元樹演算法，每次輸入（每個視角）都生成一個完整八元樹（所有提及都明確）

結果:

- 分級式演算法可以在短時間內生成一個有模糊的輪廓的模型
- 整個過程的計算數量較傳統演算法少

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7. 圖像處理過程

7.1 相機參數校準

a)一個放置在轉盤上的六邊形

b) -find the zero crossings（過零率） in the band-pass filter（帶通濾波器）ed image

-use the gradient of the filtered image to compute the edge orientations

-throwaway weak edges

c)用霍夫變換找出圖像中的直綫

d)將所有直綫分爲三個一組，找出最佳的三組直綫並組成一個六邊形

最後，六邊形的中心和6個端點用來估測攝影機參數

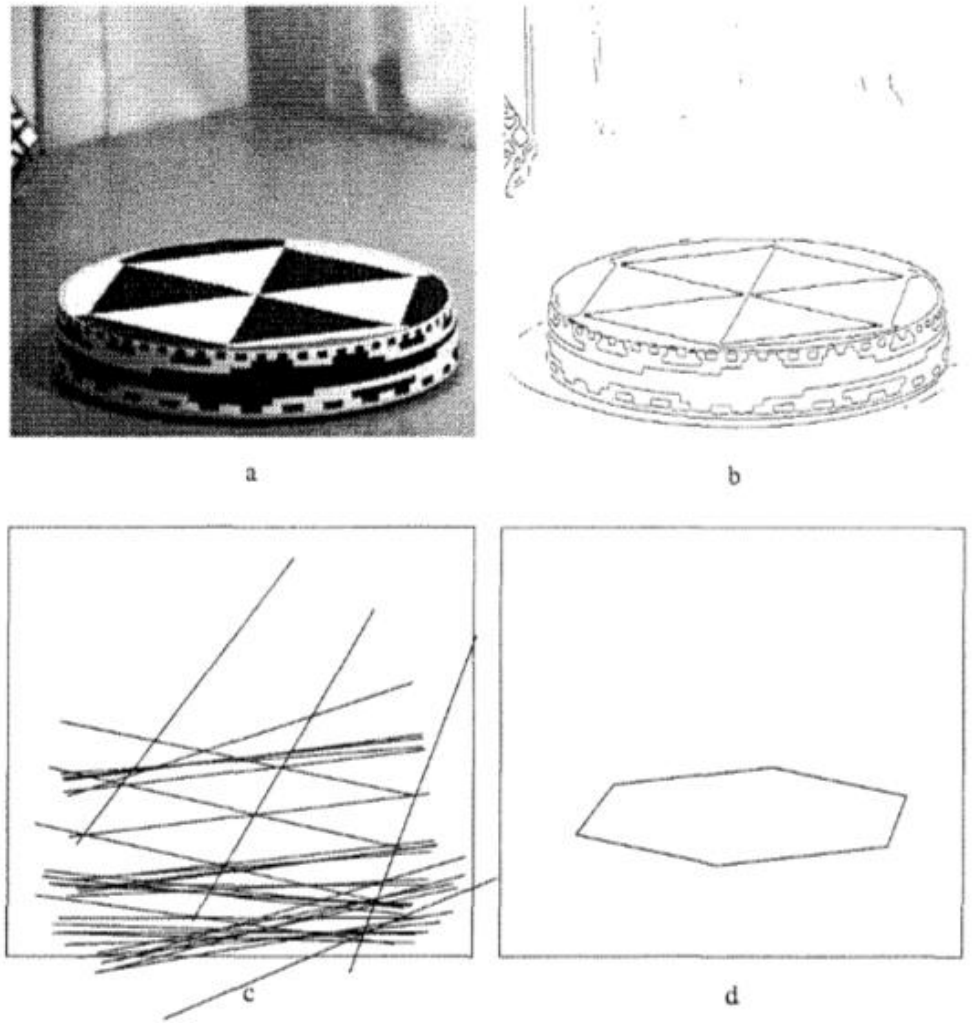

FIG. 5. Camera parameter computation: (a) hexagonal calibration pattern, (b) edges extracted, (c) lines fitted, (d) hexagon found.

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7. 圖像處理過程

7.2 角度預估

預估（所拍攝照片的）轉盤的角度

"...we look for the 8-bit binary pattern affixed to the side of the turntable The sequence of binary patterns follows a Gray code, where only one bit changes at a time."

轉盤側壁上為定位碼，藉助格雷碼進行估測

FIG. 6. Input image of object (cup), turntable, and position coding ring.

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7. 圖像處理過程

7.3調試和二值化（Adaptation and Thresholding）

*二值化（英語：Thresholding）是圖像分割的一種最簡單的方法。二值化可以把灰度圖像轉換成二值圖像。把大於某個**臨界灰度值**的像素灰度設為灰度極大值，把小於這個值的像素灰度設為灰度極小值，從而實現二值化。

用這種辦法判斷像素是否爲屬於物體的部分（區分物體和背景）

FIG. 7. Silhouette image: background = white; object = black/gray.

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8. 一些實際拍攝圖片測試的結果 (用到32張不同視角輸入照片)

FIG. 6. Input image of object (cup), turntable, and position coding ring.

FIG. 7. Silhouette image: background = white; object = black/gray.

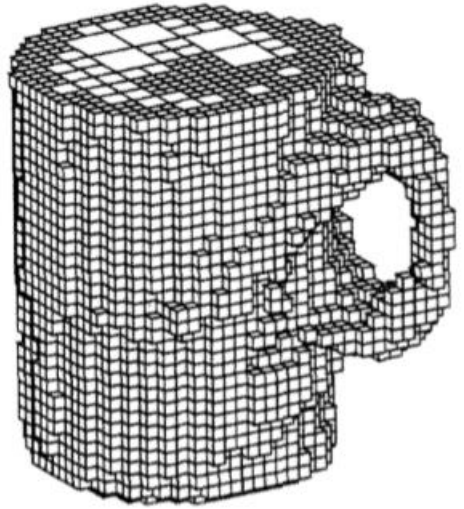

FIG. 8. Octree model derived from real cup images.

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8. 一些實際拍攝圖片測試的結果 (用到24張不同視角輸入照片)

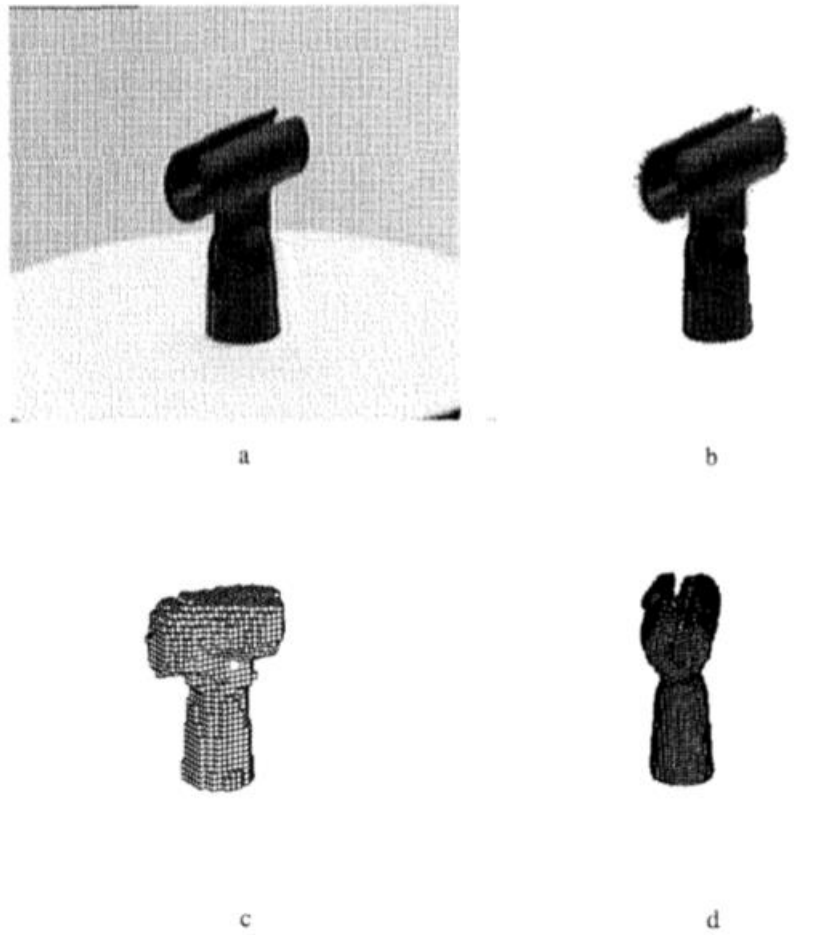

FIG. 9. Microphone stand image sequence: (a) input image, (b) silhouette image, (c) octree at resolution 5, (d) octree at resolution 6.

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9. 拓展:
改變相機位置及物體在轉盤上的位置的嘗試

10. 本文演算法與其他研究的比較