3D Reconstruction from Single 2D Image Based on Silhouette Optimization

Abstract—**In order to overcome the shortcomings of the shape from shading (SFS) algorithm in items of clearness and smoothness of silhouette in reconstructed objects, a modified SFS algorithm is proposed in this paper. Firstly, we determine the primary factors affecting reconstruction by analyzing the Lambertian light reflection model. Secondly, we perform image restoration and background smoothing by extracting object silhouette using edge detection to separate the object and background. Finally the object is reconstructed using the SFS algorithm. Theory and simulation results show that, compared with the traditional algorithms, the performance of the modified algorithm was efficiently improved, which can improve the accuracy of the reconstructed shape and the continuity of the silhouette of reconstructed objects by reducing the reconstruction error effectively.**

A. Lambertain illumination model

$R\ p\ q\ = I_e\rho\quad \theta\ \ I_e\rho\quad \angle\ n\ s$

I_e ρ

θ s

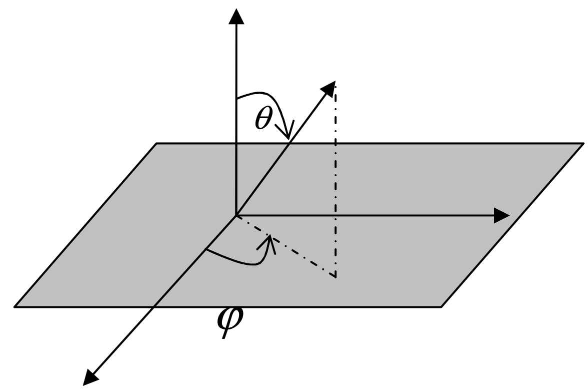
n

(x, y) *R (p ,q)*

(x,y)

p q p q

x y



B. SFS algorithm

$n = \ p\ q\ -$

(x, y) $n_s = \ p_i\ q_i\ -$

θ

$$\theta = \frac{n_i \times n}{\left\| n_i \times n \right\|}$$

$$= \rho \frac{pp_i + qq_i +}{\sqrt{p_i\ + q_i\ +}\ \sqrt{p\ \ + q\ \ +}}$$

$I\ \ x\ \ y\ \ = R\ \ p\ \ x\ \ y\ \ \ q\ \ x\ \ y$

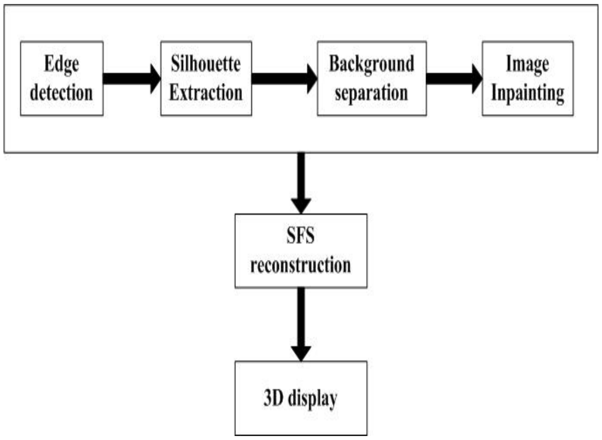
I(x, y)

(x, y)

E(x, y)

$I\ x\ y\ = R\ \ p\ \ q$

$$= \rho \frac{pp_i + qq_i +}{\sqrt{p_i\ + q_i\ +}\ + \sqrt{p\ \ + q\ \ +}}$$



A. Silhouette extraction of 2D information

E1

E2

$E \subset E$ *E,* *E*

E1 *E2.*

B. Background separation and image inpainting

E_{avg}

E_{avg} E_{avg}

$$E_{new}\ x\ y\ = \begin{cases} E_{avg}\ x\ y & x\ y \in E_{backgroud} \\ E_{old}\ x\ y & x\ y \in E_{subs\ \ ce} \end{cases}$$

$E_{background}$

$E_{substance}$

$$\frac{\partial u}{\partial t} = \nabla \left| \frac{\nabla u}{|\nabla u|} \right| + \lambda_e \ u - u$$

u

D

C. 3D image reconstruction

$$p = \frac{\partial z}{\partial x} = z \ x \ y \ - z \ x - \ y$$

$$q = \frac{\partial z}{\partial x} = z \ x \ y \ - z \ x \ y -$$

$z = f(x, y),$ (x, y)

$(Oxyz)$

$R\ (p, q)$

(x, y) $E(x, y)$

$$f\ z\ x\ y \ \approx f\ z^{n-}\ x\ y + z\ x\ y - z^{n-}\ x\ y \ \frac{d}{dz\ x\ y}\ z^{n-}\ x\ y$$

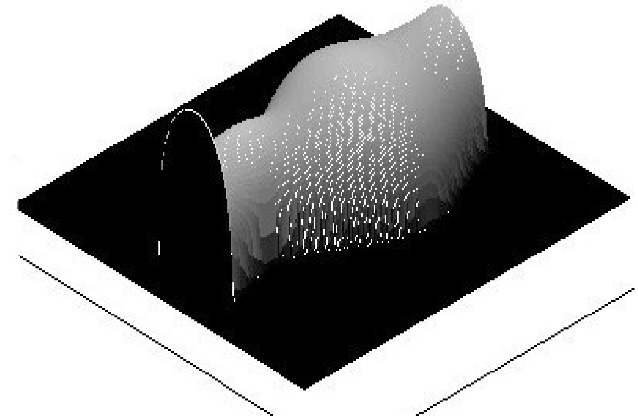
$=$

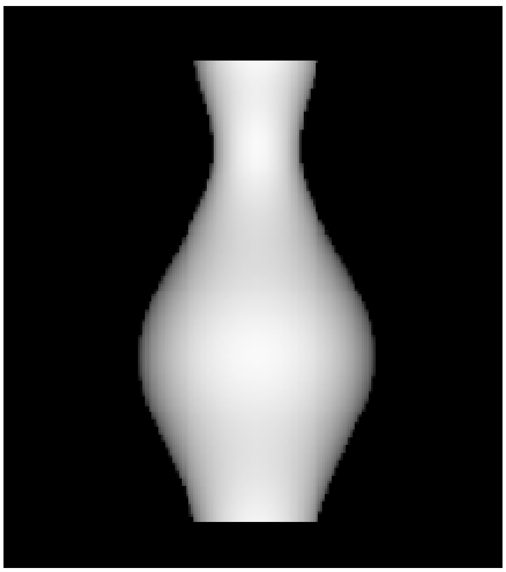
$$z^{n}\ x\ y = z^{n-}\ x\ y + \frac{-f\ z^{n-}\ x\ y}{\frac{d}{dz\ x\ y} f\ z^{n-}\ x\ y}$$

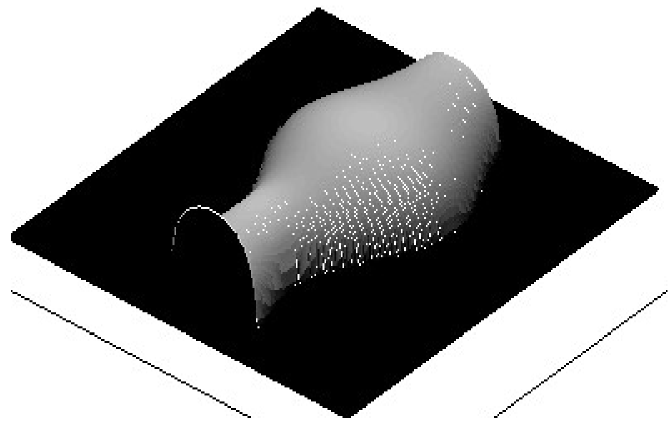
$$\frac{df\ z^{n-}\ x\ y}{dz\ x\ y} = \frac{p_i + q_i}{\sqrt{p_i + q_i +} + \sqrt{p + q +}} - \frac{pp_i + qq_i +}{\sqrt{p_i + q_i +} + \sqrt{p + q +}}$$

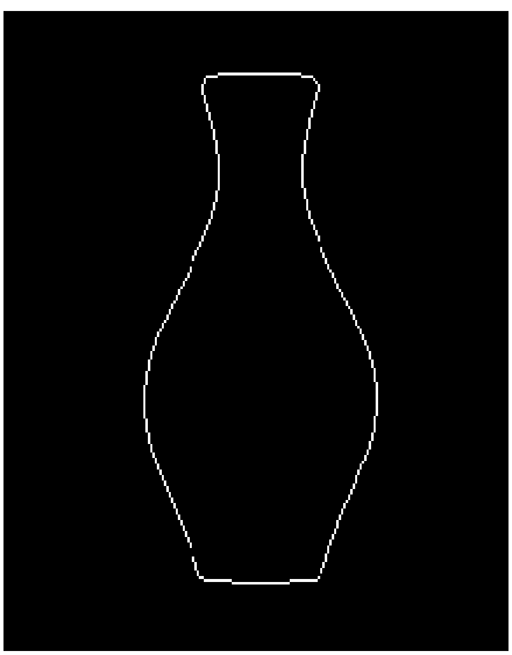
$z^{0}(x, y) = 0$

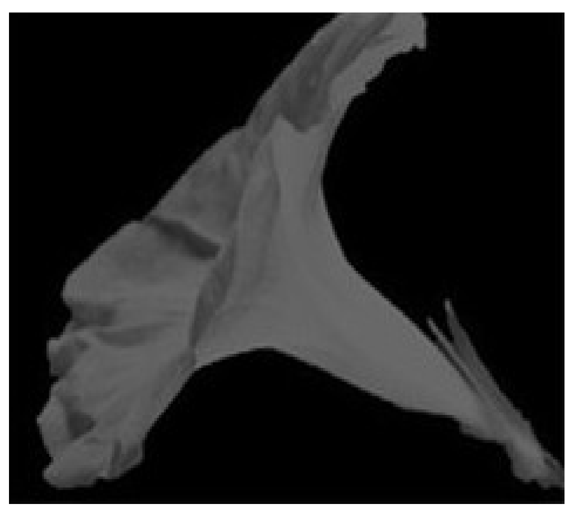
Algorithm	Error of height		
	average	*maximum*	*Time/s*

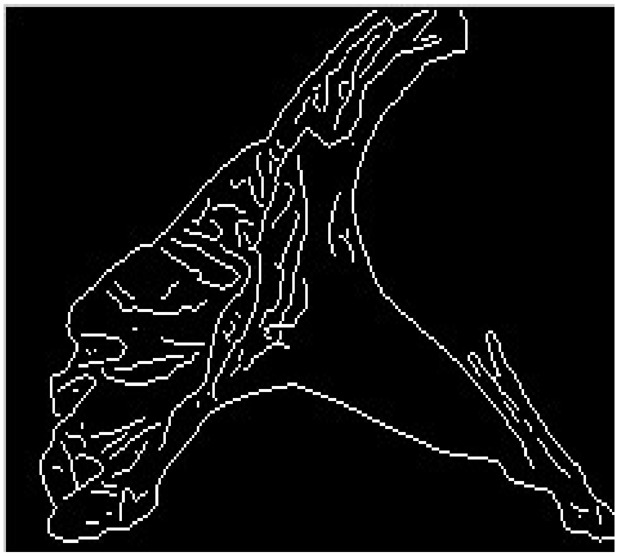


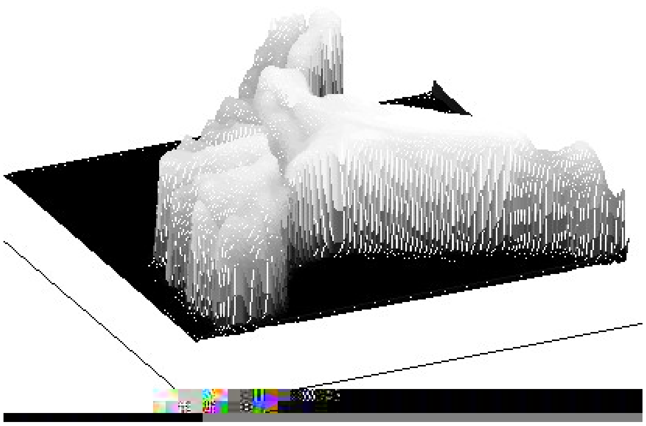


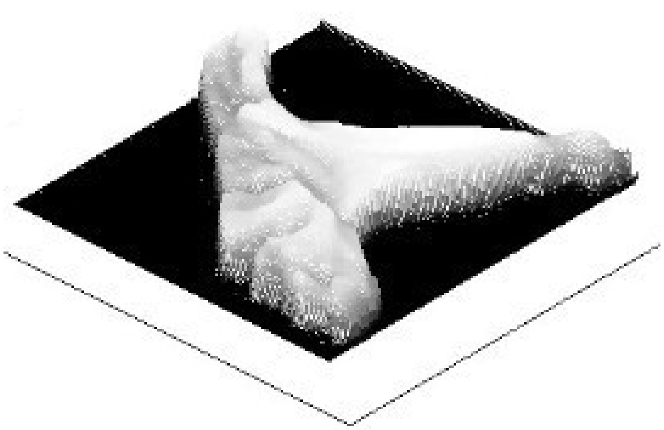












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