Non-Contact Measurements of Rill Geometry and Flow Characteristics Based on Photogrammetry

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Introduction

- ✓ Photogrammetry is widely used in detecting micro changes of landscape morphologies.
- ✓ Accurate measurements of rill geometry and flow parameters provide theoretical basis for erosion model based-process and its control.
- ✓ Measuring methods for flow depth cannot be fully applied in overland flow due to shallow flow depth (centimeter scale), high sediment concentration and variable and movable rill channel bed.

Hypothesis & Theories

Hypothesis: 1) the changes of channel depth keep constant in a short period of time; 2) rill depth and rill flow depth during inflow are calculated based on interpolation principal.

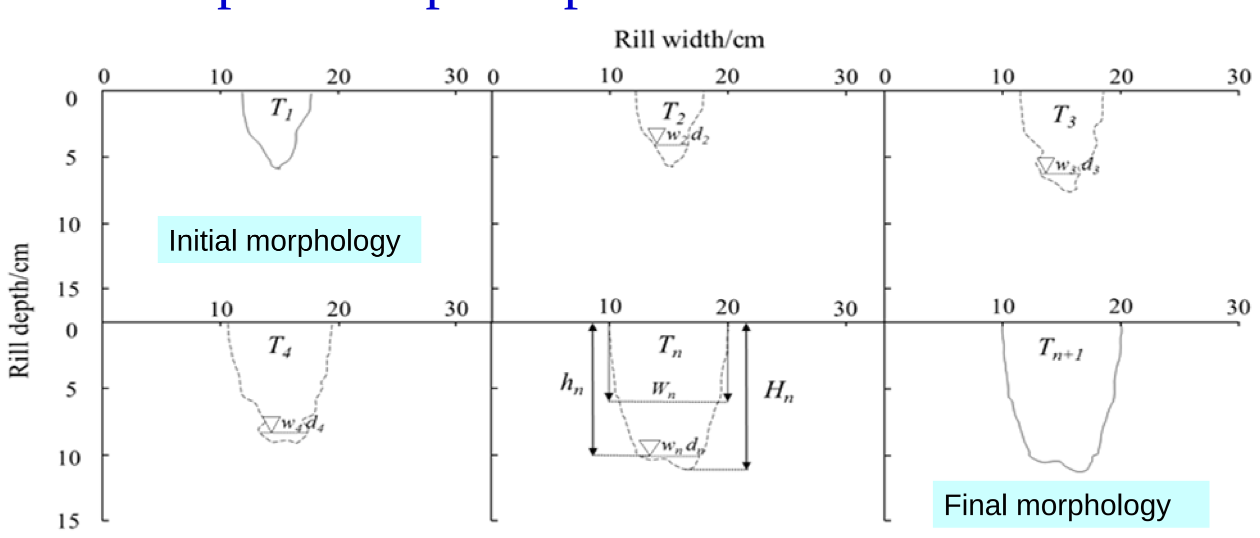

Fig. 1 Sketch of rill cross-sections at different time phases.

$$H_m = H_1 + \frac{T_m - T_2}{(n-2)t}(H_{n+1} - H_1)$$

$$H_m = h_m + d_m$$

$$d_m = H_1 + \frac{T_m - T_2}{(n-2)t}(H_{n+1} - H_1) - h_m$$

Nomenclature:

T_m: the m th shooting time (m = 2, 3..n)

H_m: Real channel depth at shooting time m

H_1: Real channel depth at shooting time 1

h_m: Characterized channel depth gained from photogrammetry at shooting time m

d_m: Channel flow depth at shooting time m

Materials & Methods

Fig. 2 Development processes of a well developed rill channel.

What we need:

- ➢ Two cameras;
- ➢ A stable frame;
- ➢ Some targets;
- ➢ An infrared remote control.

What we need:

- ➢ A well developed rill channel;
- ➢ Constant inflow;
- ➢ ArcGIS;
- ➢ Agisoft Photoscan.

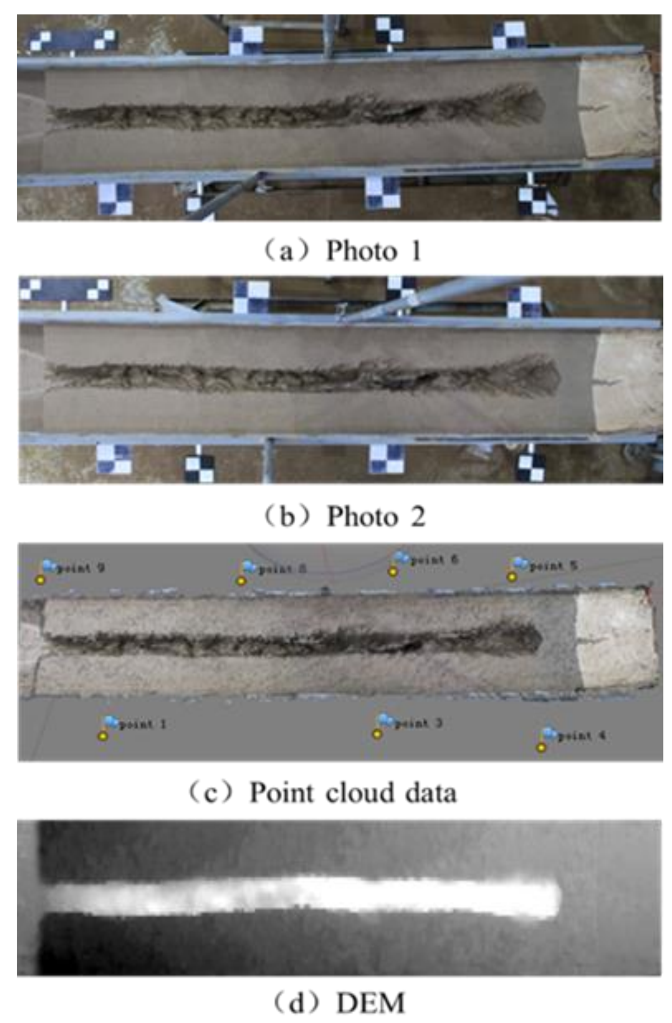

Fig. 3 A pair of photos obtained from photogrammetry, point cloud data and DEM.

Setting cameras:

Position: paralleled to soil surface

Shooting: RAW

Scene mode: manual

Aperture: largest

ISO: lowest

Shutter speed: medium

Focus: manual

Supplying inflow:

constant inflow during 10-130 sec experiment time.

Taking pictures:

every 10 sec.

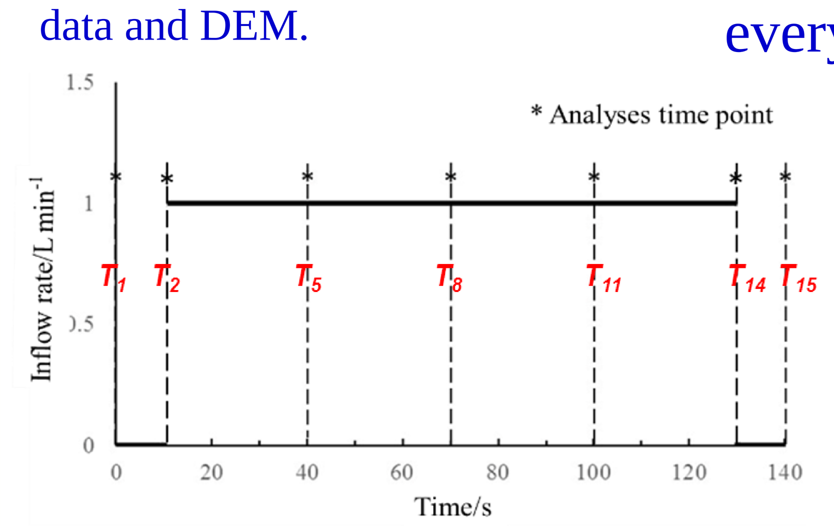

Fig. 4 Flow chart of experiment processes.

What we compare: measuring rill geometry and rill flow characteristics using traditional method during shooting intervals.

Results

Table 1 Measured real rill depth and measured rill width at the time of T_1 and T_{15}. cm

S_D/(°)	S_L	T_1		T_{15}		ΔH	ΔW
		H_1	W_1	H_{15}	W_{15}		
15	142	6.45	7.33	7.37	8.08	0.92	0.75
	108	5.41	8.61	6.32	9.29	0.91	0.68
	74	5.78	7.08	6.58	7.60	0.80	0.52
	40	1.50	6.31	2.98	6.64	1.48	0.33
20	142	6.27	8.32	7.94	9.49	1.67	1.17
	108	5.06	8.17	7.20	9.28	2.14	1.11
	74	4.02	10.06	5.60	10.60	1.58	0.54
	40	1.01	8.58	2.75	8.80	1.74	0.22

Table 2 Characterized real rill depth and measured rill width at the time of T_5, T_8 and T_{11}. cm

S_D/(°)	S_L	T_5		T_8		T_{11}	
		H_5	W_5	H_8	W_8	H_{11}	W_{11}
15	142	6.68	7.65	6.91	7.71	7.14	8.07
	108	5.64	8.74	5.87	8.93	6.09	9.08
	74	5.98	7.25	6.18	7.33	6.38	7.44
	40	1.87	6.39	2.24	6.58	2.61	6.55
20	142	6.69	8.66	7.11	8.91	7.52	9.46
	108	5.60	8.40	6.13	8.73	6.67	8.99
	74	4.42	10.18	4.81	10.33	5.21	10.58
	40	1.45	8.60	1.88	8.69	2.32	8.73

Table 3 Characterized rill depth, calculated rill flow depth and measured rill flow width at the time of T_2, T_5, T_8, T_{11} and T_{14}. cm

S_D/(°)	S_L	T_2			T_5			T_8			T_{11}			T_{14}		
		h_2	d_2	w_2	h_5	d_5	w_5	h_8	d_8	w_8	h_{11}	d_{11}	w_{11}	h_{14}	d_{14}	w_{14}
15	142	6.28	0.17	1.66	6.50	0.18	1.77	6.72	0.19	1.73	6.93	0.21	1.85	7.15	0.22	1.76
	108	5.29	0.12	2.85	5.49	0.15	2.69	5.72	0.15	2.64	5.91	0.18	2.55	6.13	0.19	2.89
	74	5.60	0.18	3.25	5.78	0.20	3.10	5.97	0.21	3.19	6.16	0.22	3.29	6.36	0.22	3.16
	40	1.38	0.12	4.43	1.74	0.13	3.69	2.09	0.15	3.58	2.46	0.15	3.40	2.79	0.19	3.32
20	142	6.12	0.15	1.64	6.53	0.16	1.66	6.95	0.16	1.64	7.35	0.17	1.66	7.77	0.17	1.64
	108	4.88	0.18	2.38	5.43	0.17	2.40	5.96	0.17	2.46	6.48	0.19	2.28	7.02	0.18	2.21
	74	3.85	0.17	3.01	4.26	0.16	3.15	4.64	0.17	3.20	5.03	0.18	3.17	5.40	0.20	3.01
	40	0.83	0.18	3.75	1.26	0.19	3.66	1.68	0.20	3.42	2.11	0.21	3.79	2.54	0.21	3.64

- ➢ Increasing rates of rill widths and depths under 20° slope were 1.7 and 1.3 times those under 15° slope.
- ➢ Rill flow widths under 15° slope were 1.7%-13.1% larger than under 20° slope, while rill flow depths showed little difference between the two slopes.

Discussions

Table 4 Rill depth, width and rill flow depth, width measured by manual measurement with steel ruler and photogrammetry.

Bed slope /(°)	Slope length /cm	Method	H		W		d		w	
			Avg	Dev	Avg	Dev	Avg	Dev	Avg	Dev
15	108	Manual	6.0	0.41	9.0	0.47	0.4	0.05	3.2	0.32
		Photogrammetry	5.81	0.39	8.89	0.30	0.16	0.03	2.72	0.14
	74	Manual	6.4	0.48	7.3	0.27	0.4	0.04	3.3	0.22
		Photogrammetry	6.13	0.34	7.32	0.22	0.21	0.02	3.20	0.07
20	108	Manual	6.3	1.08	8.7	0.52	0.3	0.05	2.7	0.23
		Photogrammetry	6.00	0.91	8.64	0.48	0.18	0.01	2.35	0.10
	74	Manual	5.0	0.76	10.4	0.26	0.4	0.05	3.4	0.22
		Photogrammetry	4.71	0.67	10.29	0.23	0.18	0.02	3.11	0.09

- ❖ Rill depths and rill flow depths obtained by manual measurements with a steel ruler were 3.3%-5.1% and 91.0%-178.5% higher than those obtained by photogrammetry.

Conclusions

- ❖ Rill width and rill flow width could be directly measured from perpendicularly shot photographs after proportional scale calibration.
- ❖ Rill depth and rill flow depth could be measured and calculated based on interpolation principal.
- ❖ Compared with traditional methods and 3D laser scanning (Lidar), photogrammetry has **speed, resolution** and **non-contact** advantages and it can also **overcome rill wall shield** and **prevent the occurrence of point cloud "black holes".**

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http://www.cnki.net/kcms/detail/11.1964.S.20160902.0853.004.html