SfM多視点写真測量による地形データのTLSを用いた精度検証

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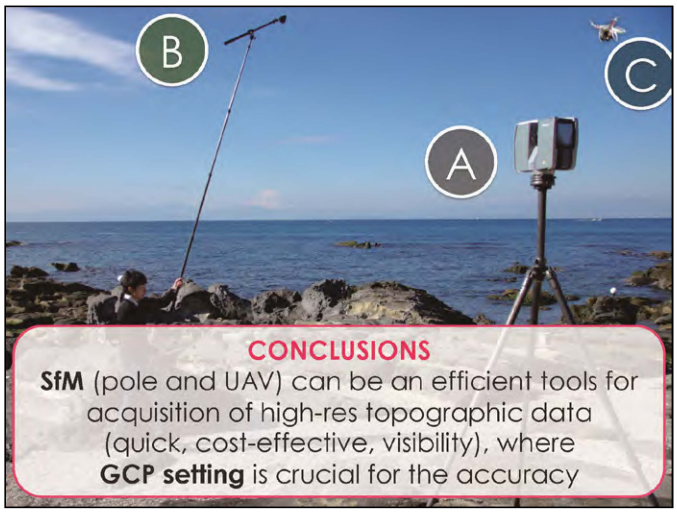
油壺海岸での検証事例

ROCKY COASTAL BENCH AT MIURA PENINSULA



CONCLUSIONS

SfM (pole and UAV) can be an efficient tools for acquisition of high-res topographic data (quick, cost-effective, visibility), where **GCP setting** is crucial for the accuracy

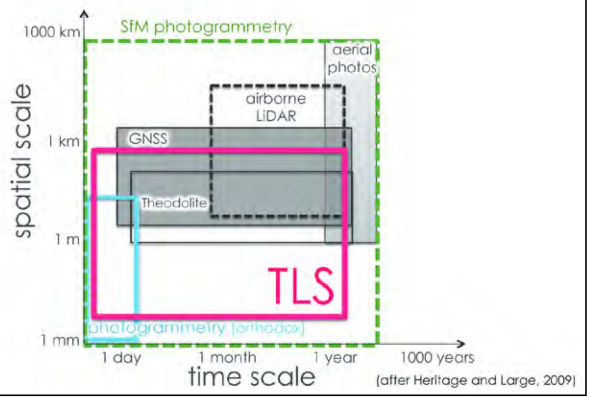
INTRODUCTION

High-resolution topography

– emerging methods –

high-res satellite images (photogrammetry)
aerial photography (photogrammetry)
airborne laser scanning
terrestrial laser scanning
robotic total station
kinematic GNSS
ground-based photography (photogrammetry)
…

Time and spatial scales for various methods



among else,

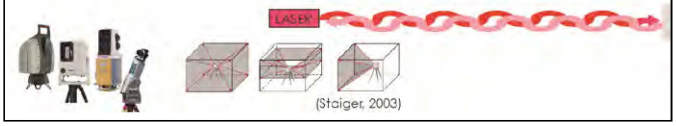
TLS terrestrial laser scanning — A

SfM structure-from-motion — B C

these are becoming popular in geosciences

TLS

- ground-based LiDAR (Light Detection And Ranging)
  - distance to a target by laser beams
- Laser emission
  - Measurable without visible light
- Quick acquisition of large point cloud



(Staiger, 2003)

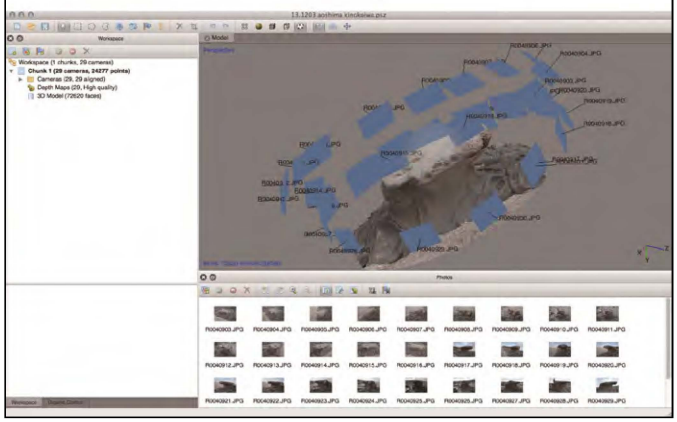
SfM-MVS photogrammetry

- **SfM**: structure from motion
  - reconstructing camera positions in 3D from 2D images
  - developed in computer vision (Ullman, 1979; Szeliski, 2010)
  - sparse point cloud (matched points)
- **MVS**: multi-view stereo
  - photogrammetry using aligned photos
  - dense point cloud

in Japanese...?

SfM多視点写真測量

2D photos to 3D model



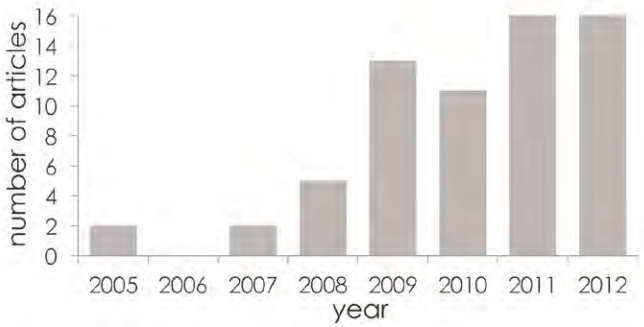
features of SfM-MVS

- platform-free
  - UAV (UAS), balloon
  - pole, handheld
- cost-effective
  - possible with <1,000 USD

    (cf. TLS >50k USD)
- multiscale
  - mm ~ km
- high resolution
  - often >1M points or faces
- textured
  - orthophoto

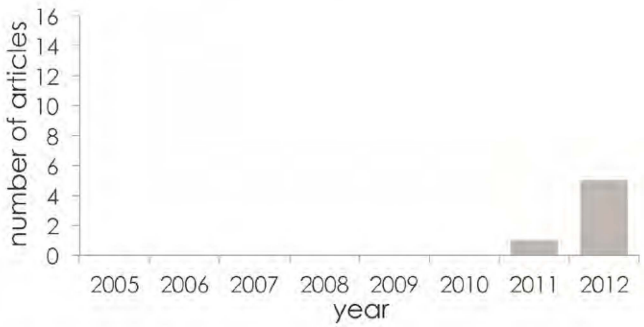
    (cf. point cloud by TLS)

num. of papers on TLS



The data was retrieved from GeoRef, a bibliography database in geosciences, using keywords of [terrestrial AND laser AND geomorphology].

num. of papers on SfM



The data was retrieved from GeoRef, a bibliography database in geosciences, using keywords of ["structure from motion"].

as an early stage,

quantitative evaluation of these emerging methodologies is necessary

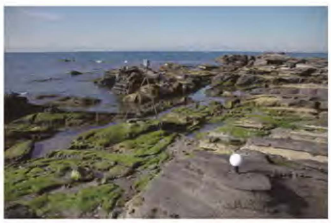
how accurate?

how effective?

STUDY AREA

STUDY AREA

A rocky coast at Aburatsubo, Miura Peninsula



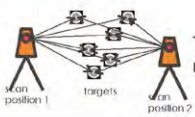
(国土地理院の電子地形図25000を使用, 定形図郭では「三浦・三崎」の一部)

ca. 190 m x 50 m
uplifted intertidal bench
less people, less vegetation, slightly undulated

TLS – terrestrial laser scanning

- Trimble TX5 (OEM: FARO Focus3D)
  - lightweight: 5 kg
  - short range: ~120 m
  - fast: ~ 900,000 pts/sec
- measurement
  - ca. 9 min for each position
  - sphere/flat targets for registration

A



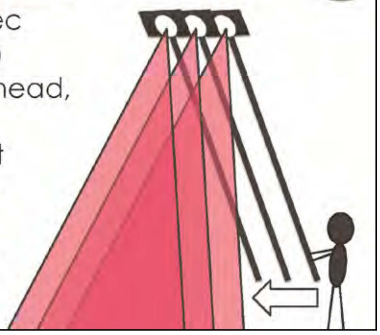
Tie-point registration

Pole-camera SfM

- 4-m long rod
- RICOH GR

B

- interval shutter: 1 sec
  - fixed aperture (F5.6)
- gradually moves ahead, keeping overlaps
- shoot from different angles as much as possible
- post-processing by Agisoft PhotoScan



UAV-SfM

- DJI PHAMTOM
  - payload: ca. 400 g
  - flight height: ca. 20–30 m
- Nikon COOLPIX A
  - 16 MPix
  - ca. 300 g
  - 1/500 sec, F4.5–11
  - 1-sec interval
- post-processing by Agisoft PhotoScan

C

reference points

- for georeference of obtained point clouds
- 3 GCPs
- GNSS receiver
  - Trimble GeoXH Explorer 6000
    - antenna: Trimble Zephyer 2
  - post-processed accuracy
    - **~9 cm** in X, Y and Z

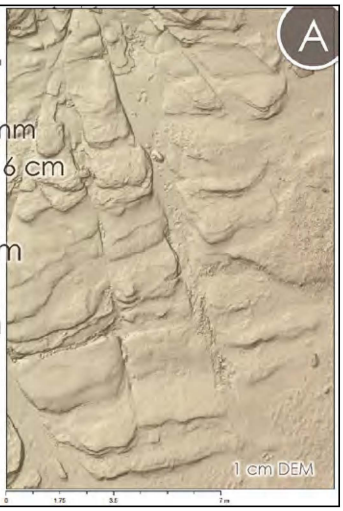
©Trimble

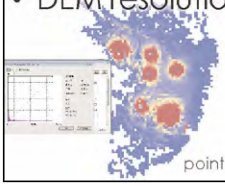
RESULTS & DISCUSSION

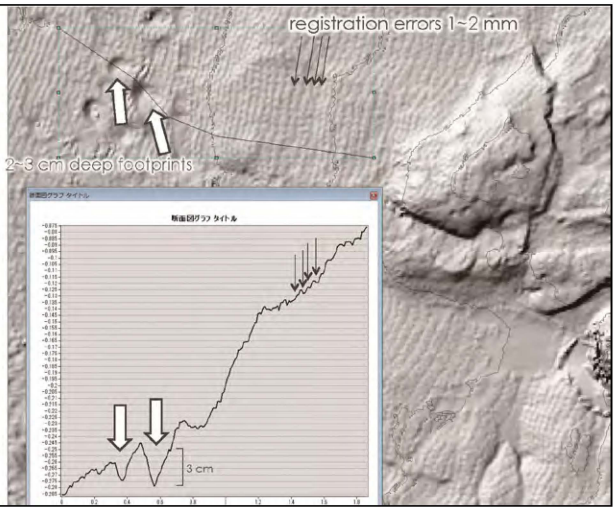
TLS

- 6 scan positions
  - registration error: ~2 mm
  - georeference error < 6 cm
- ca. 1 hr
- point spacing: 9.2 mm (max 1.3 mm)
- DEM resolution: 1 cm

A



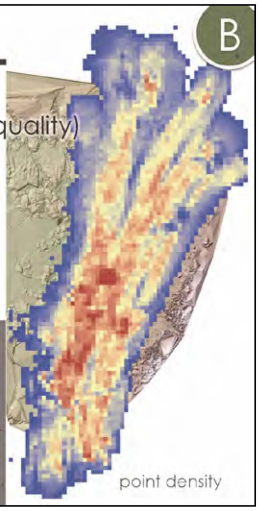




pole-camera SfM

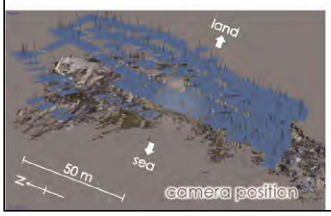
- 1,273 photos
  → ca. 181M points (medium quality)
  - ca. 17 hrs (align & dense cloud)
- georeference errors: 4–7 cm
- point spacing: 22 mm (max 9.5 mm)
- DEM resolution: 2 cm

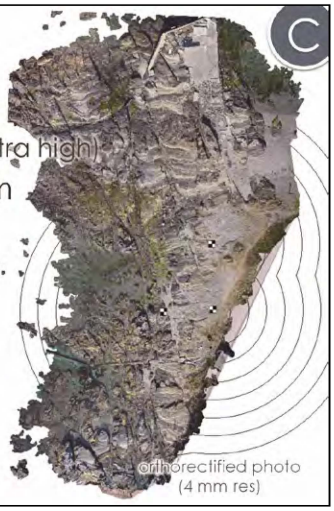
B



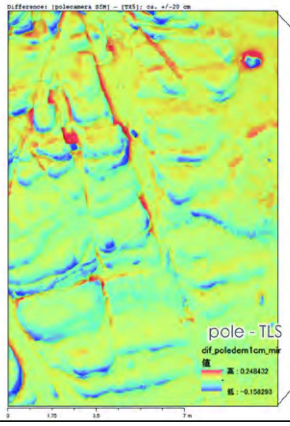
UAV-SfM

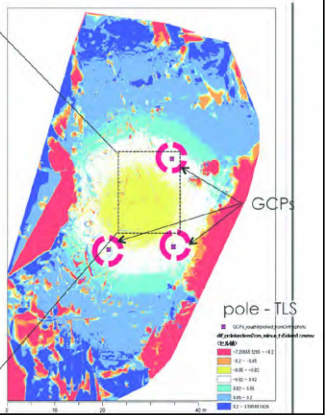
- 335 photos
  → ca. 470M points (ultra high)
- point spacing: 3.8 mm (max 0.67 mm)
- DEM resolution: 4 mm.



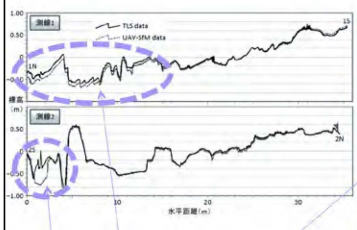


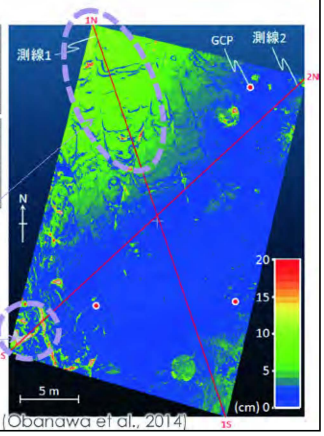
Pole-camera SfM vs. TLS





UAV-SfM vs. TLS





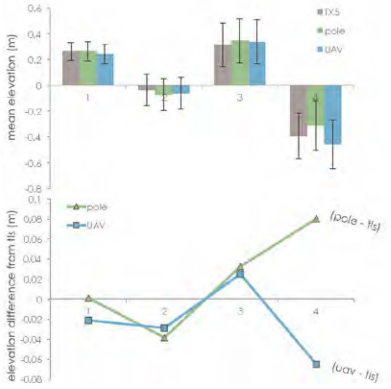
away from GCPs

discrepancies at edges and water areas

(Obanawa et al., 2014)

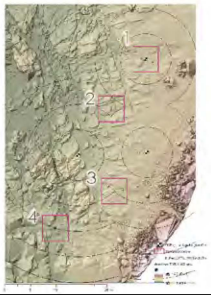
Pole-SfM & UAV-SfM vs. TLS elevation (by 2-cm DEM)

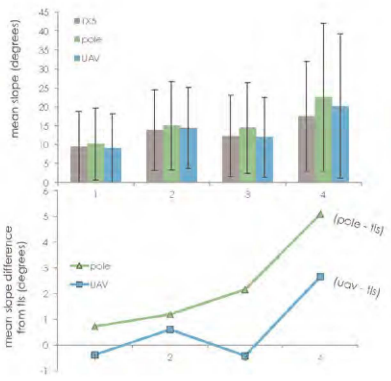
5 m x 5 m test squares
1. 0 m from a target
2. 10 m from 3 targets
3. 10 m from 2 targets
4. 15 m from a target



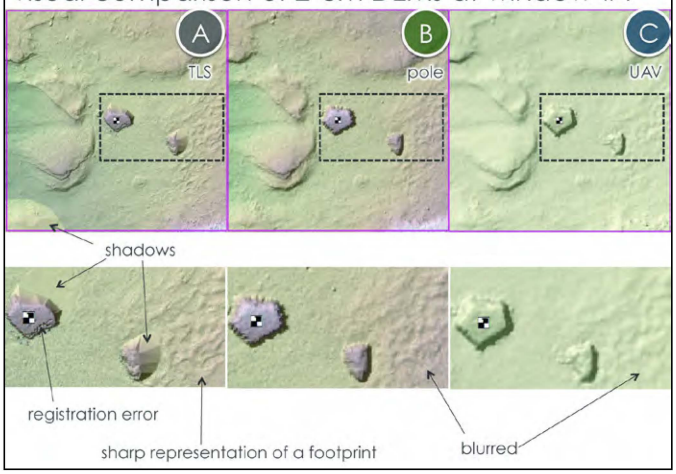
Pole-SfM & UAV-SfM vs. TLS slope (by 2-cm DEM)

5 m x 5 m test squares
1. 0 m from a target
2. 10 m from 3 targets
3. 10 m from 2 targets
4. 15 m from a target





visual comparison of 2-cm DEMs at window #1



summary

	TLS	pole camera SfM	UAV SfM
time on site	★ 1 hour (multiple scan)	★★ 0.5–1 hour	★★★ 0.5 hour
time for post processing	★★ several hours	★ 10– hours	★ 10– hours
cost	☹ JPY 5M–30M	★★★ JPY 50k–100k	★★ JPY 200k–2M
resolution & representation	★★★ 1–10 mm	★★ 10 mm	★ 10–20 mm
relative accuracy	★★★ 2–3 mm	★ ~10 cm	★ ~10 cm
visibility (shadow)	★	★★★	★★
visibility (RGB)	★ only point cloud	★★★ orthophoto	★★★ orthophoto
water	N/A unless green laser	★★ if clean water	★★ if clean water

- SfM (pole and UAV) can be an efficient tools for acquisition of high-resolution topographic data (quick, cost-effective, visibility)
- GCP setting is crucial for the accuracy of SfM data