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Special Track: MLS-RSUAV: Machine Learning and Classical Signal Processing Algorithms Applied to Robotics and Sensor Data Collected from UAVs Security Solutions for Mission Critical Applications

# 3D Reconstruction with Drone Images: Optimization by Reinforcement Learning

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# About Authors Presenting

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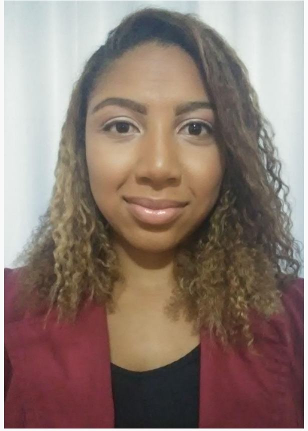

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# Outline

**Summary**

- Introduction
- Methodology
- Experiments
- Discussion of Results
- Conclusion / work in progress

# Introduction

- Increasing need for geometric 3D models
  - ➔ Movie industry, games, virtual environments, simulators;
    Inspect details to ambiental researches [1], historical heritage [2], support military missions …
- Existing solutions are not fully satisfying
  - ➔ User-driven modeling: long and error-prone
  - ➔ 3D scanners: costly and cumbersome
- Alternative: analyzing image sequences
  - ➔ UAVs increase mobility and multiples softwares
  - ➔ Cameras are cheap and lightweight
  - ➔ Cameras are precise (several megapixels)

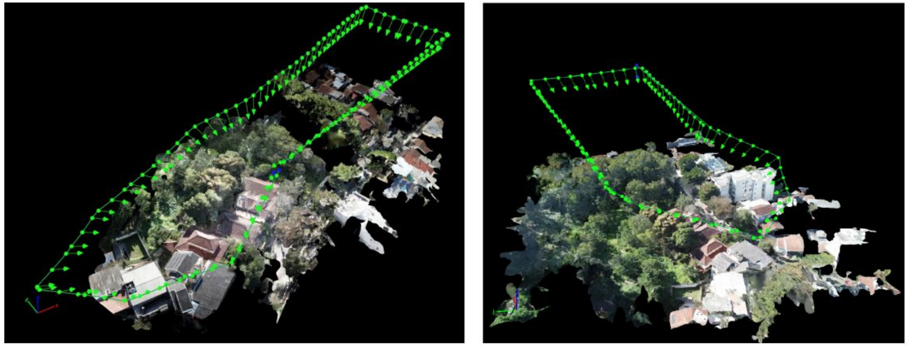
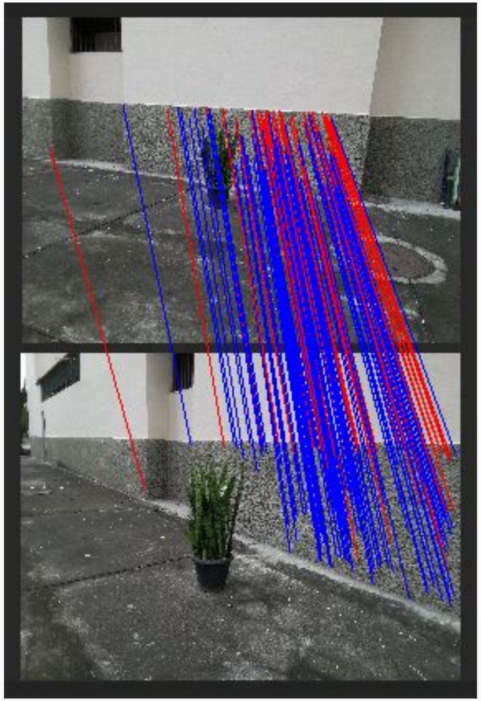
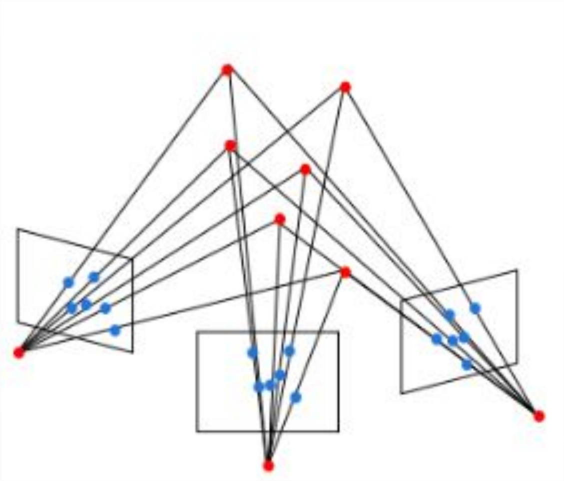


Figure 1. Mapped and reconstructed outdoor area.

# Methodology - 3D Reconstruction Pipeline



Feature extract and Matching [3]



Multiview geometry [4]

Point cloud

# Methodology - Structure for Motion

- Structure from motion uses referenced relative motion for inference about 3D geometry;
- Camera poses (position + orientation) are resolved automatically;
- Use of adjustment from image set (bundle adjustment)

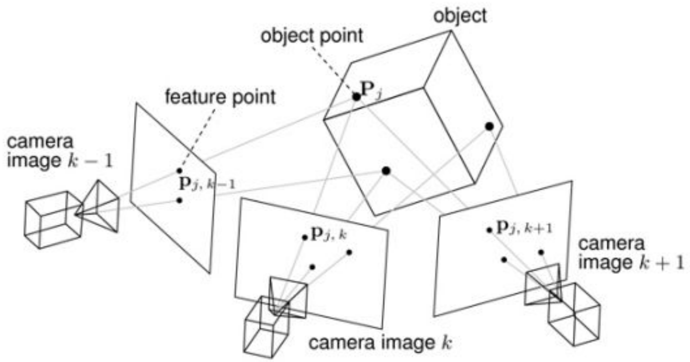
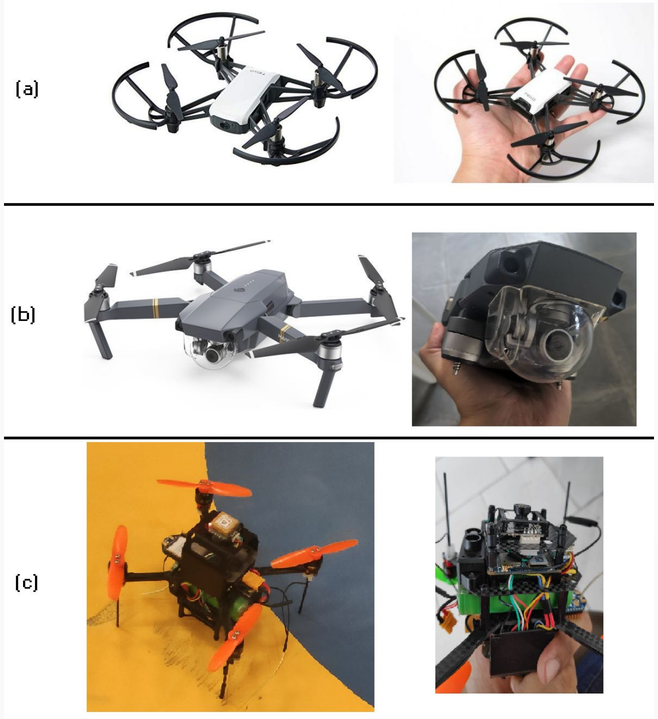



Figure 2. Result after structure-from-motion estimation. The projection of a 3D object point Pj in the camera image at time k gives the tracked 2D feature point $P_{j,k}$ [5]

# Experiments - UAVs and Datasets




| Dataset generated | Acquisition Device | Images | PIX4D | Meta-shape | ODM | RC |
|---|---|---|---|---|---|---|
| Crystal's valley | Mavic Pro (b) | 337 | x | x | x | |
| BOC 60 - High Res. | Mavic Pro (b) | 302 | x | x | x | |
| BOC 60 - Med. Res. | Mavic Pro (b) | 169 | x | x | x | |
| BOC 60 - Low Res. | Mavic Pro (b) | 138 | x | x | x | |
| LARC | Sub-250 (c) | 150 | x | x | | |
| PIRF - Fan Scene | Tello (a) | 62 | | | | x |
| PIRF - Human Scene | Tello (a) | 50 | | | x | x |
| PIRF - Bags Scene | Smartphone | 217 | x | | | |
| Object - Plant | Tello (a) | 35 | x | x | | x |
| Object - Robot | Smartphone | 154 | x | | | |
| Object - Castell | Smartphone | 64 | x | x | x | x |

Table I

GENERATED DATASETS, IMAGES AND RECONSTRUCTION SOFTWARES USED.

# Experiment Outdoor– BOC 60

Resolutions: High (302), Medium(169) and Low(139) [6].

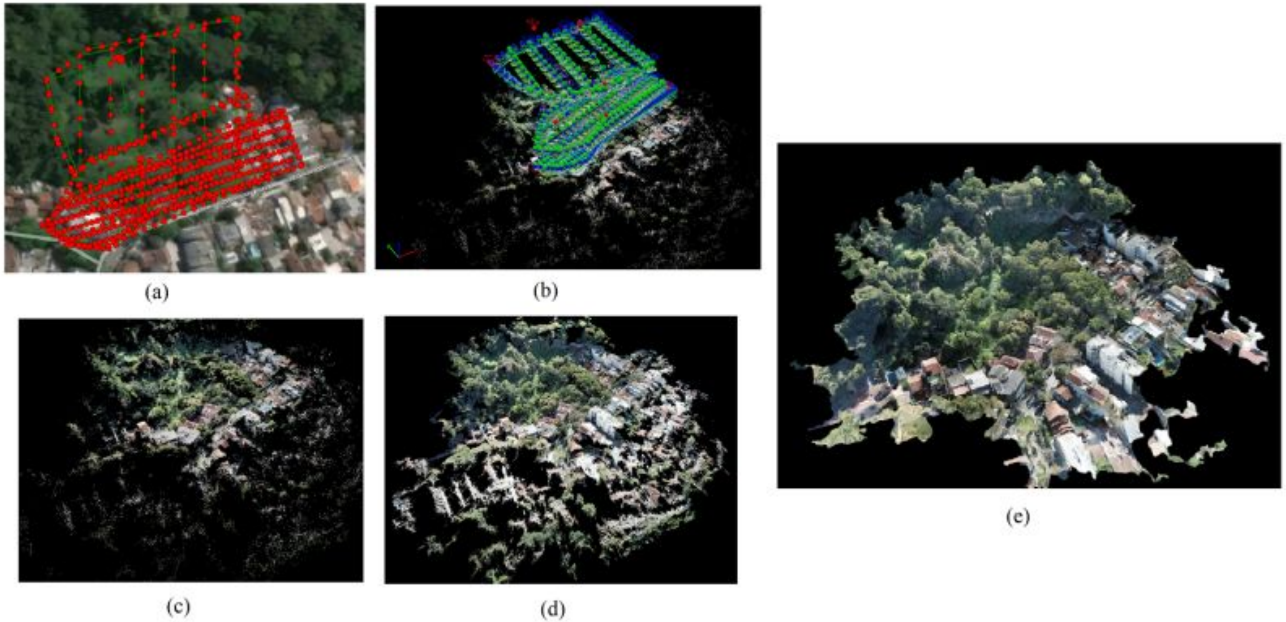


Figure 3. BOC 60 Steps to Rebuild PIX4D software; (a) Snapshot points on the map; (b) 3D image taking points; (c) Tie Points; (d) Dense cloud of points; (e) Textured 3D Model.

# Experiment Outdoor- BOC 60

Visual comparison between PIX4D, Metashape and ODM Softwares

Pix4d Metashape Open Drone Map

# Experiment - Medieval Castle

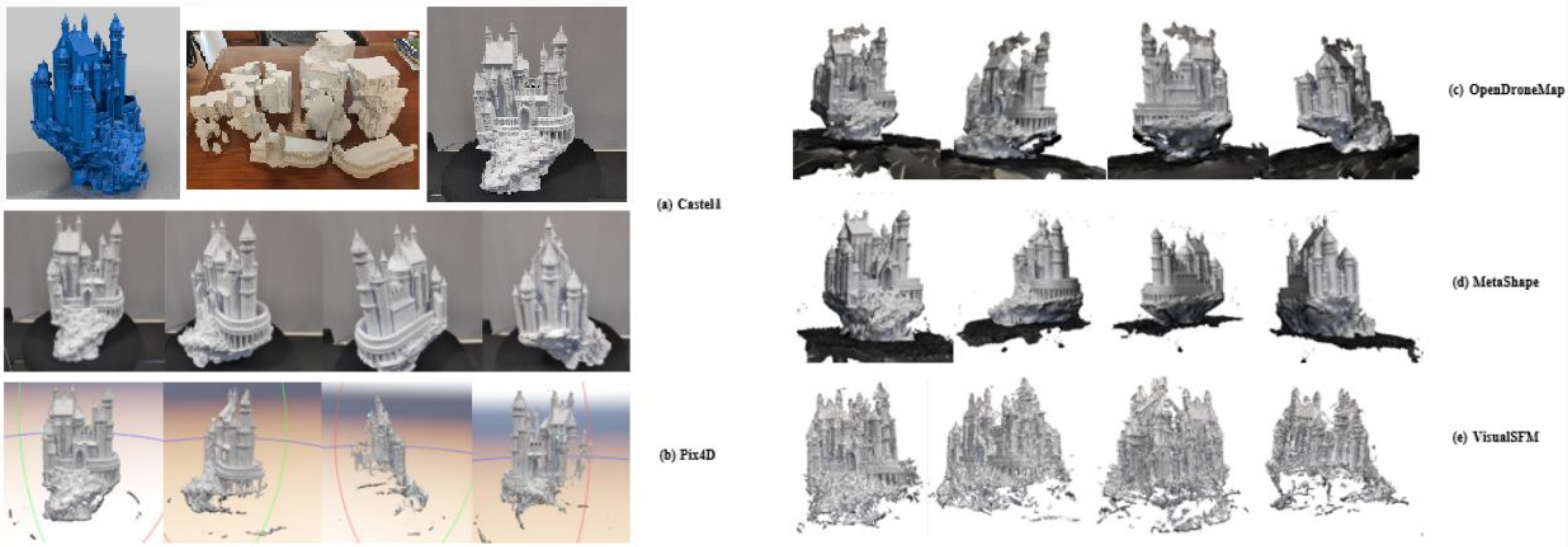



Figure 6. Medieval Castle experiment, reconstruction using different tools. [7]

# Discussion

CloudCompare software was used for comparison between point clouds [8].

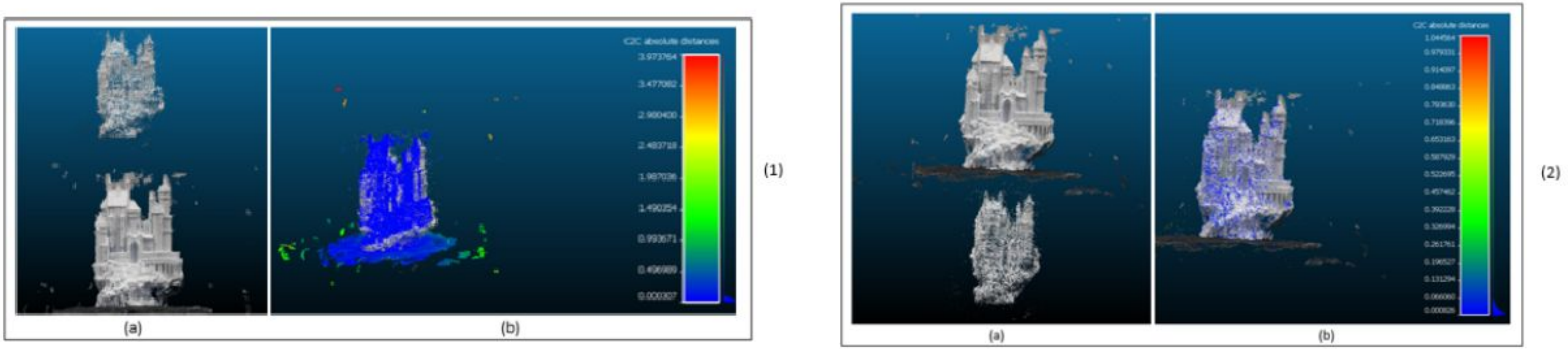



Figure 7. Comparison point cloud Metashape and OpenDroneMap. (1) Metashape reference. (2) OpenDroneMap reference. (a) Insertpoint cloud; (b) Generated heat map.

# Conclusion

- The contribution made by this project includes the creation of datasets with scenes and 3D objects;
- Use datasets for optimization experiments with machine learning and reinforcement learning in order to improve the distortions caused during image processing and also increasing the visible accuracy of the three-dimensional models.
- We conclude that it is feasible to use UAVs for imaging outdoor and indoor scenes to reconstruct objects and scenes.

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# Thanks!

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