Visionary Collaborative Outdoor Reconstruction using SLAM and SfM

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Major problems

- Scalability
  - Maintainence of large reconstructions
  - Redistribute to different clients

- Changing conditions
  - Lighting, Weather, Decay of buildings, Vegetation
  - Moving objects (Humans, Cars, …)

- Insufficient GPS accuracy
  - Often up to 40m

- Information sharing (location aware)

- Many algorithms for tracking and reconstruction, but not real-time outdoor, no mobile solutions, momentarily

- Working in the lab, but not further improved

Agarwal et al., Building Rome in a Day 2011
Changing conditions

Graz images from google search "Grazer Hauptplatz"
Collaborative SLAM

Multiuser-SLAM Server

Client management

Take 2 clients

Detection of image overlap

Get a map from pool for verification

init new map or merge client

Map management

Map-Pool

Client Pull Queue

Transformed KF, Pose

Refresh map

KF, Pose, Calib

Pull request

KF, Pose

C1

Cn

SfM Pipeline KF, Poses, Calib

SfM Pipeline KF, Poses, Calib
Collaborative SLAM

- C++
- Multithreaded
- Cuda utilization
  - Image based comparisons as cuda-tasks
- Task based
  - Every “operation” is a task
  - Cuda tasks
- Decoupled WebGL Visualization
- SfM Pipeline per client within own thread
Collaborative SLAM

https://www.youtube.com/watch?v=UIXsv3ROCVs
Changing conditions

The cloud checks if clients receive existing data or generate new. New Data is added as new version and visually and structurally matched against existing data.

- **Versioning** of 3D data
  - Different daytimes
  - Different weather conditions
  - Reply with best fitting version

- Detection of changes within same 3D data
  - Image and structure based (features, img-alignment, ICP, ...)
  - Generate / update structural changes
Partitioning the world

- Games like World of Warcraft show, by implementing world-partitioning techniques how to overcome the *thin-client-problem*
- Clients are categorized into a certain area to reduce the overall data necessary (transmission, load to memory)
- Multiple instances of dungeons
- Transition areas between different parts of the world
- GPS as selector
Clients

• Due to inaccurate GPS other localization algorithms needed → *Tracking and Mapping* (SLAM)

• Run on mobile

• Information sharing
  • Feeding the cloud (Images, 3D structure, … )
  • Clients registered to the cloud can share location aware 3D content
  • Directly tracking with received 3D data

• One client might not see enough

• Moving object detection
Clients

Ventura/Arth 2014
Future

• Plugging all together, will deliver an collaborative reconstruction system

• Can be used for precise outdoor AR, Navigation, ...

• But – lot of implementation work left

• We need to find a nice and maintainable way to efficiently store different versions of 3D structures