3D Point Cloud Analytics for Updating 3D City Models

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Background

Hasso Plattner Institute (HPI):

- Computer Graphics Systems group of Prof. Döllner
- Research in the field of analysis, planning, and construction of software systems for massive geodata
- www.hpi3d.de

HPI Hasso Plattner Institut
IT Systems Engineering | Universität Potsdam

Point Cloud Technology GmbH:

- IT solutions for the management, computational use, and visualization of large-scale, highly detailed 3D point clouds
- HPI Spin-Off
- www.pointcloudtechnology.com

POINT CLOUD TECHNOLOGY

Agenda

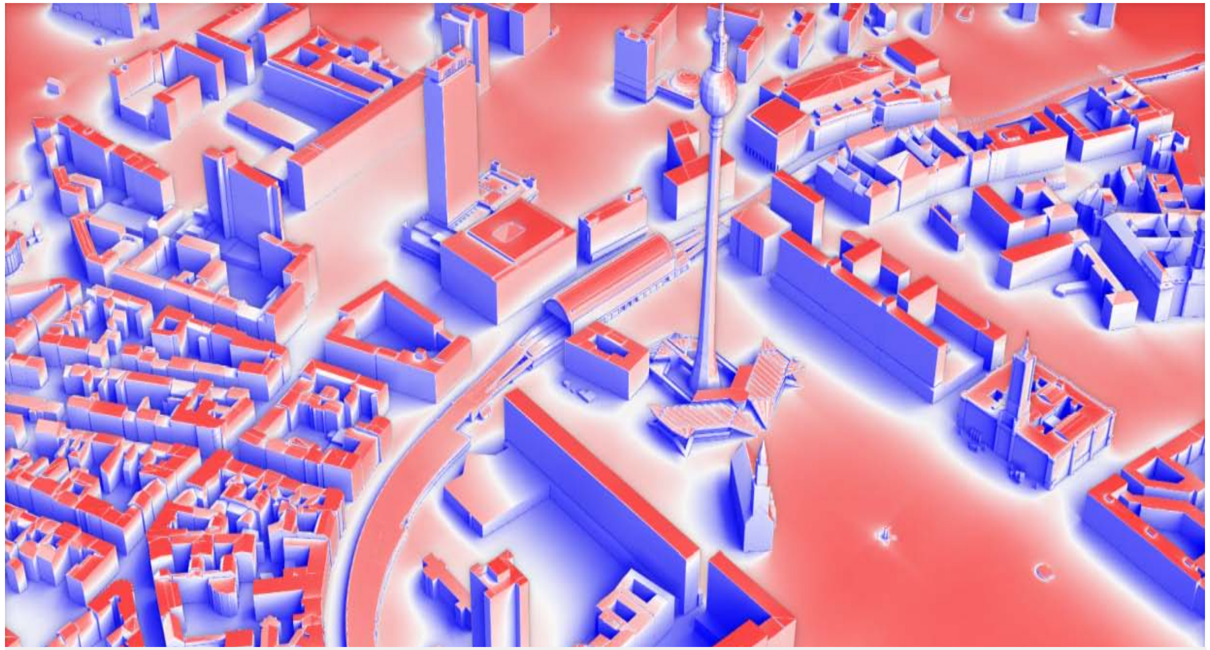
- Context & Problem
- Detection and Classification of Changes
  - Point Cloud Classification
  - Change Detection
  - Categorization of Changes
- Results and Case Study
- Conclusions

Context & Problem – Applications

"A virtual 3D city model is a digital snapshot of the reality that is aging from the date of data acquisition."

Up-to-date 3D models are required for various applications:

- Planning
- Monitoring
- Documentation
- Analyses
- Simulations
- Disaster management
- Marketing



Solar potential analysis for the 3D city model of Berlin.

Context & Problem – Applications

The preparation and construction of 3D city models require different data sources:

- Aerial images
  (e.g., orthophotos)
- 3D point clouds
  (e.g., from LiDAR or image matching)
- Surface models
  (e.g., DSM, DTM)
- Building footprints
  (e.g., ALKIS, ALK)
- Vegetation models
  (e.g., tree cadastre)
- Oblique aerial images
- …

3D point cloud + colors from aerial images.

3D city model of Berlin.

Context & Problem – Applications

1) Data acquisition is performed in regular intervals (e.g., once a year), with high resolution and coverage for cities, metropolitan areas, and countries.

2) The derivation of high-quality, semantically rich, geometrically complex and large-scale 3D city models can not be mapped to a fully automated process.

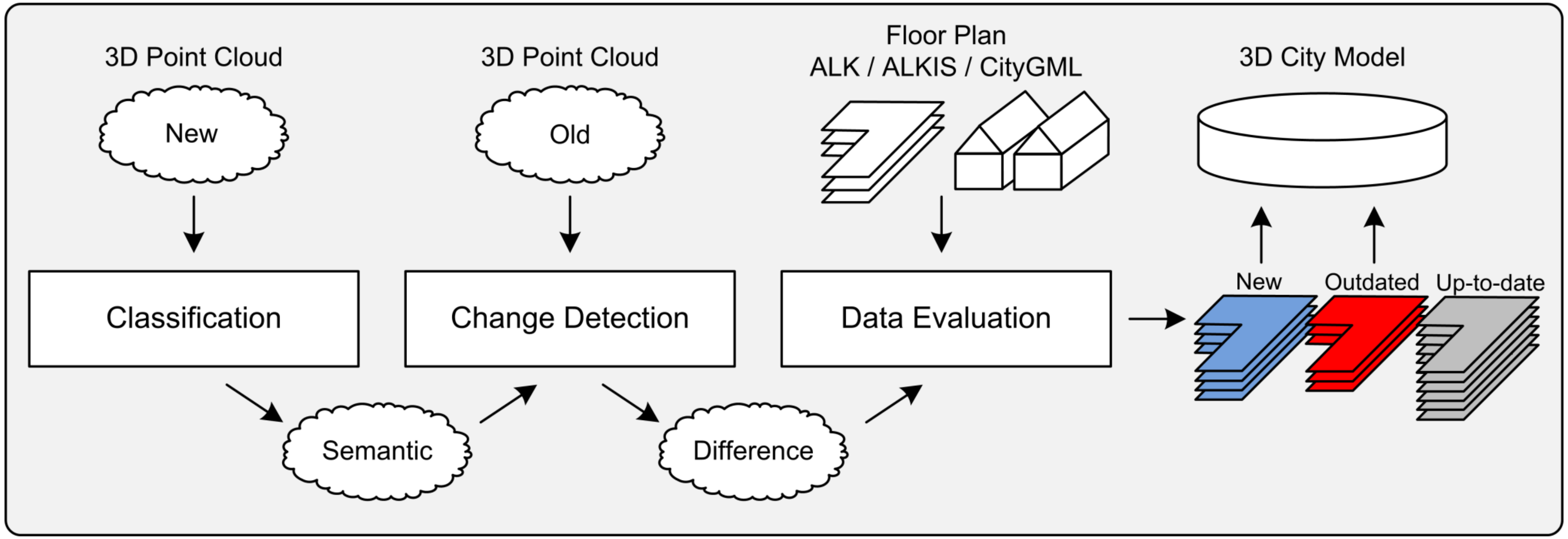
- Quality assurance, modeling, and correction requires manual effort.
- Requires time and financial resources.
- Long time span between data acquisition and availability of the 3D city model.

Geometrically complex 3D building model.

Context & Problem – Solution

Use of **multi-temporal 3D point clouds** for selective updates:

1) Classification of 3D point clouds to enable a focus on domain specific subsets of the data (e.g., ground, vegetation, building points).
2) Change Detection to identify regions that need to be updated.
3) Categorization of changes to perform selective updates.



Challenges

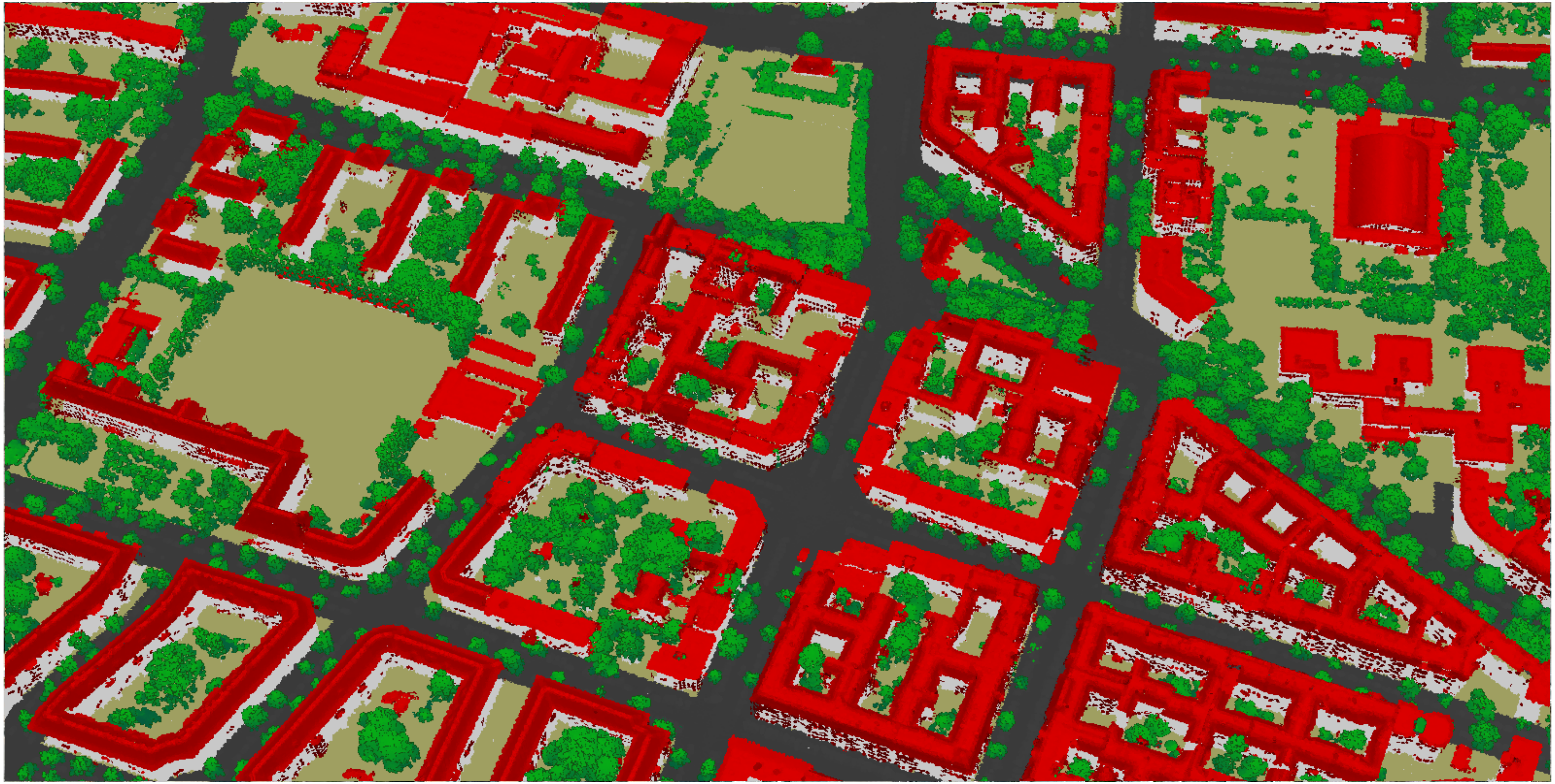
Requirements:

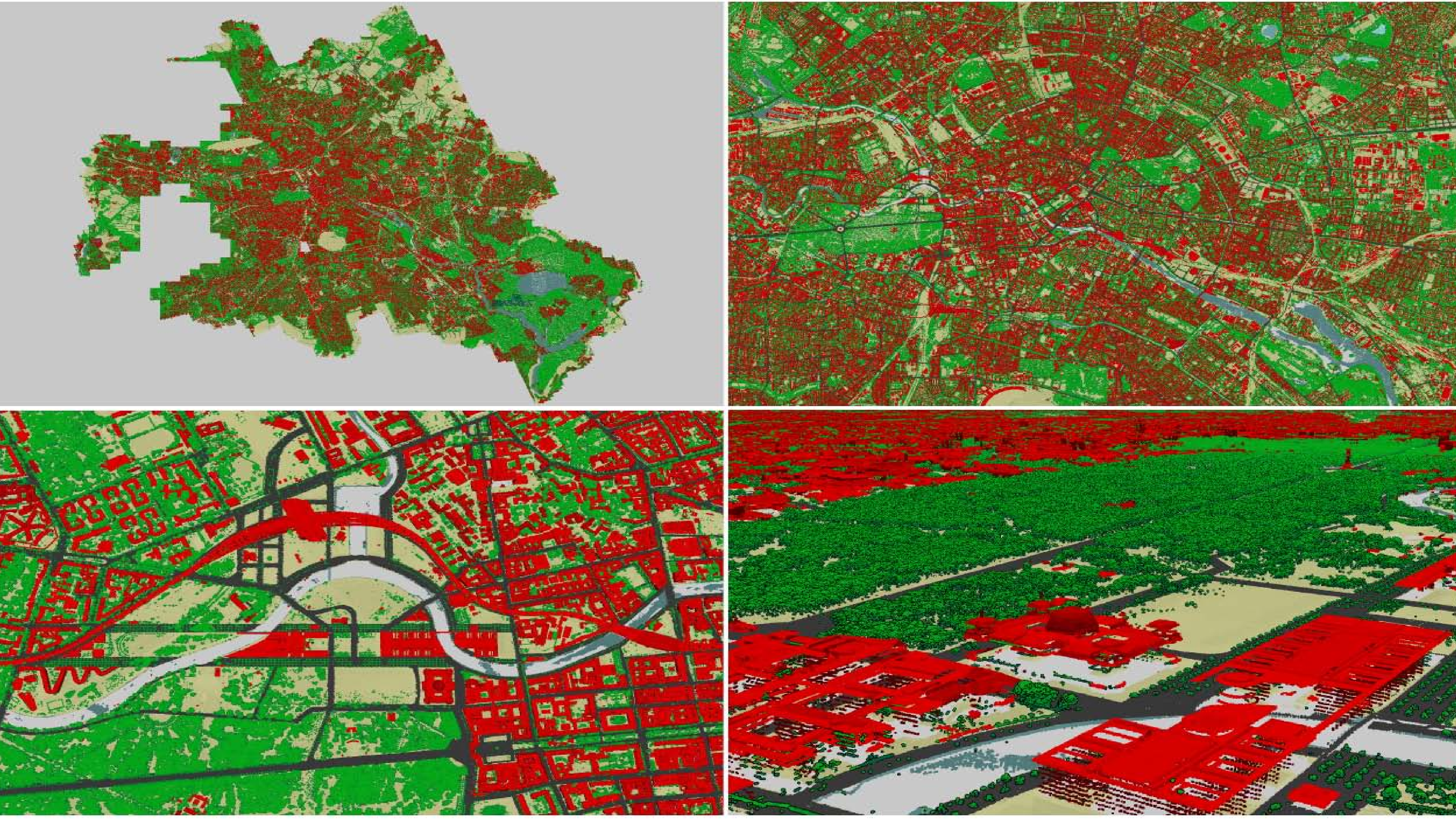
- Automatic processing
- Capability to analyze dense 3D point clouds (e.g., 100 points/m²)
- Handling of massive data sets (e.g., 100 TB data)
- Efficient processing (e.g., few days or weeks of computing time)

Data captured during an aerial scan for the urban area of a city.

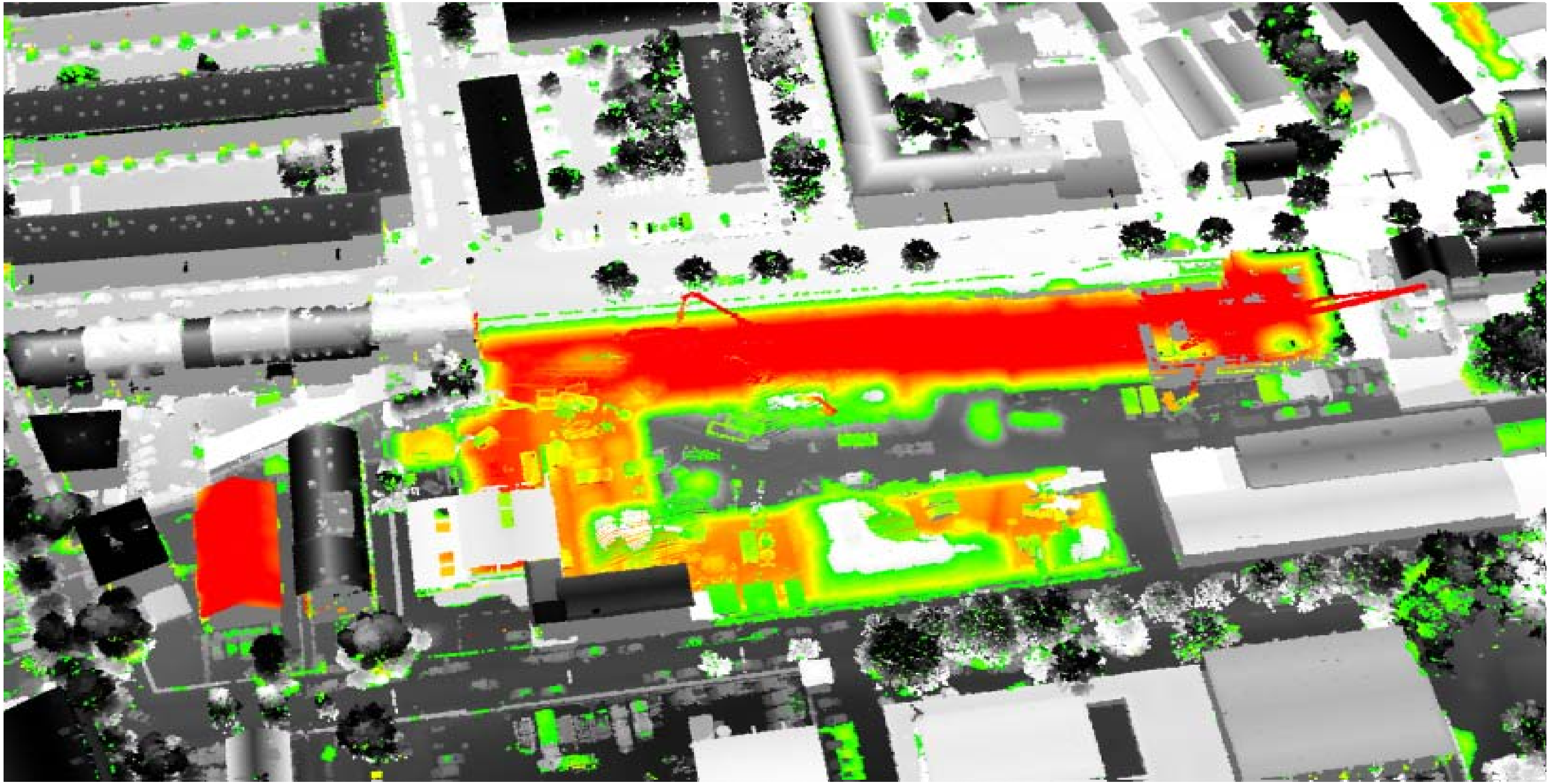
Classification of 3D Point Cloud

Classification of 3D Point Cloud



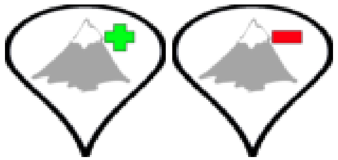


Change Detection

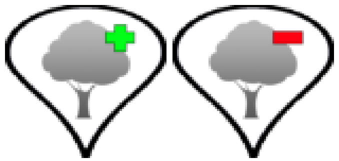


Categorization of Changes

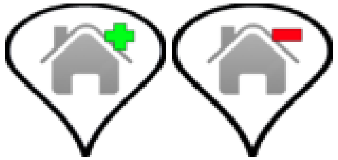
Ground:

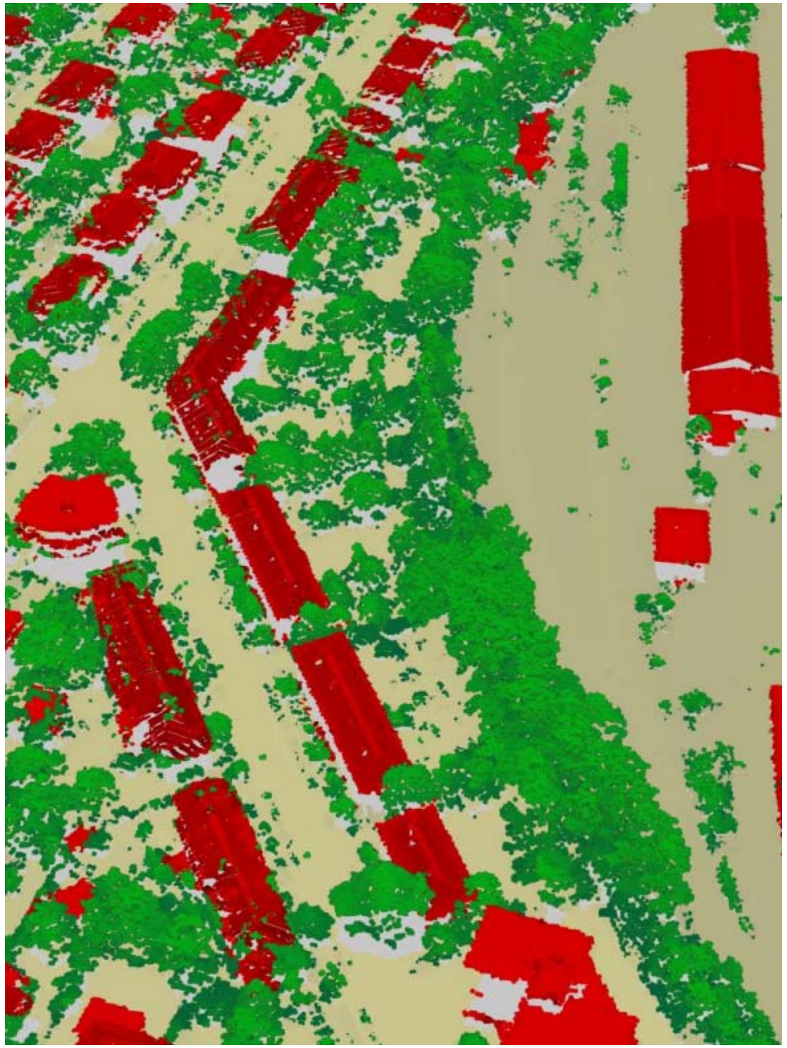


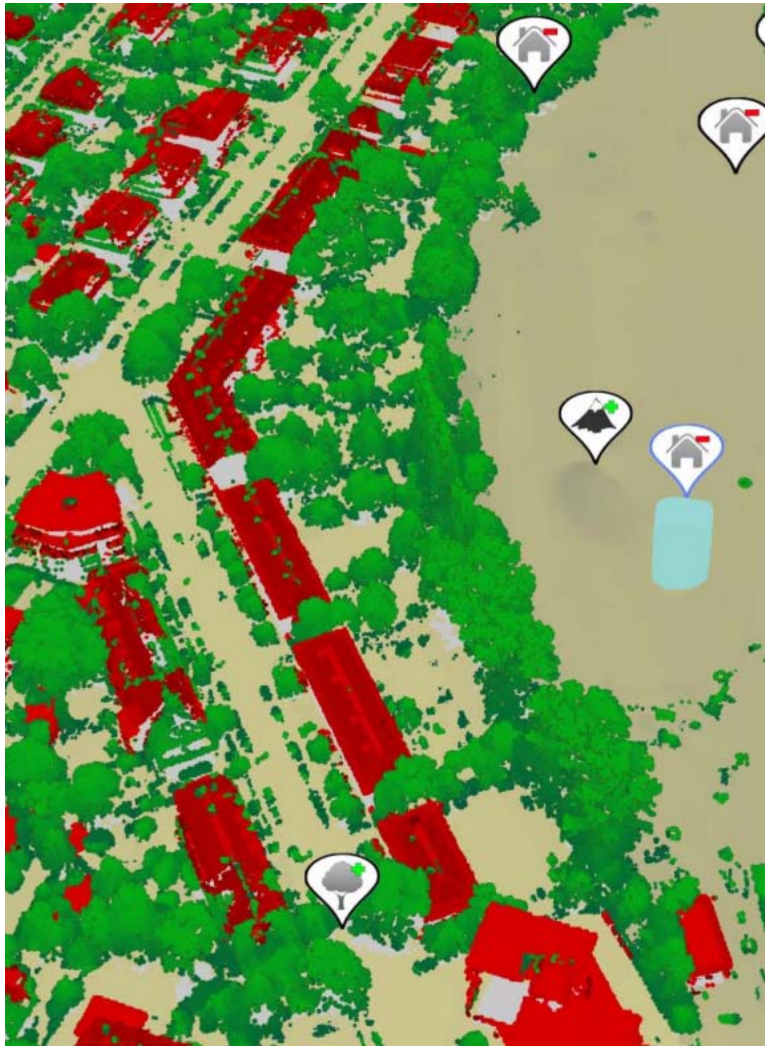
Vegetation:



Building:







Case Study Berlin

Facts:

- 890 km² urban area
- 120 TB data
- 527.000 buildings

Data:

- 3D point cloud 2009
  - 5-10 points/m²
  - 5 Bil. points
- 3D point cloud 2013
  - 100 points/m²
  - 80 Bil. points
  - Building footprints

Partners:

Berlin Partner für Wirtschaft und Technologie

virtualcitySYSTEMS

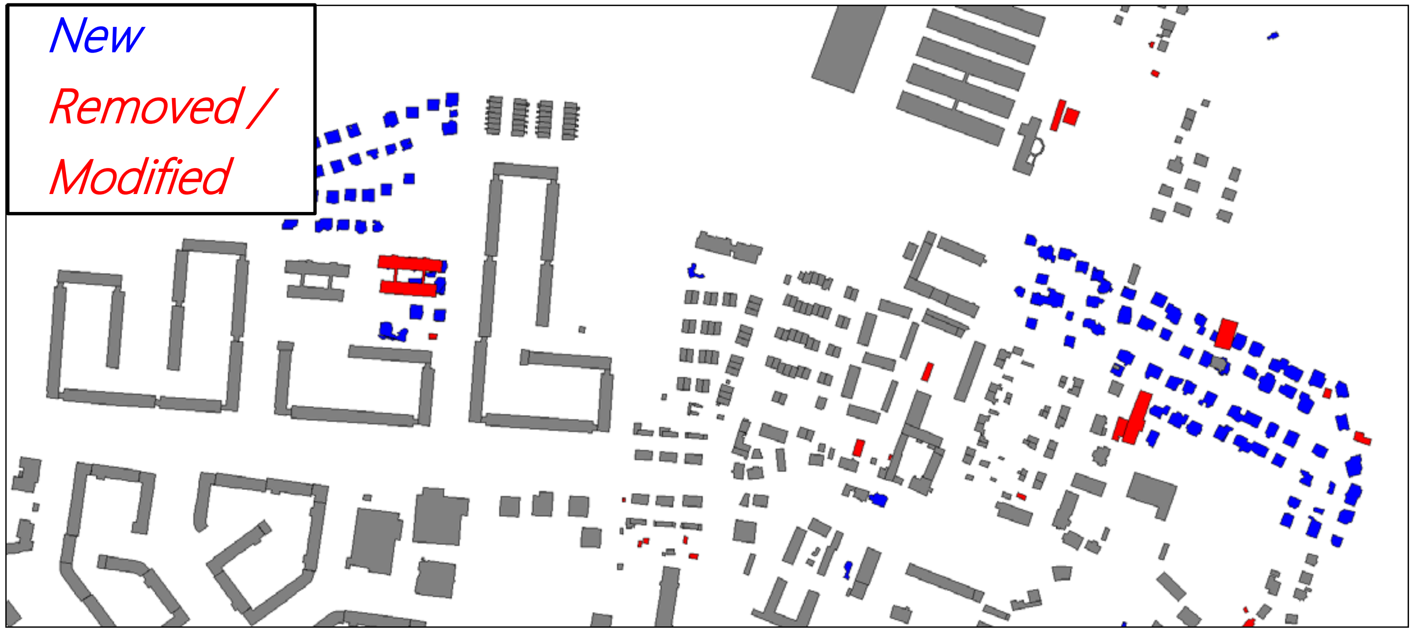
be Berlin Senatsverwaltung für Wirtschaft, Technologie und Forschung

Classified 3D point cloud.

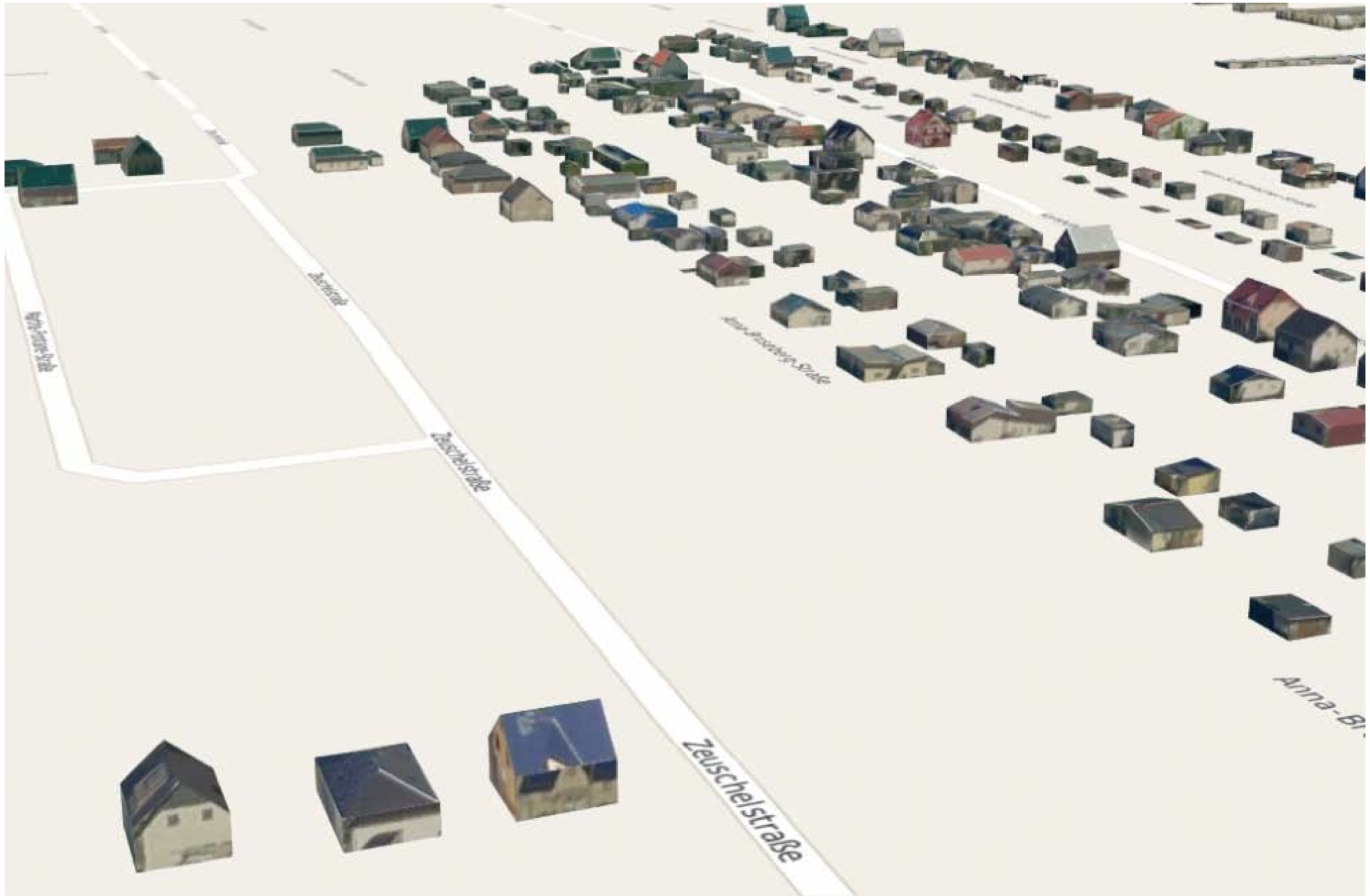
Case Study Berlin – Goal

Detection of **new, removed**, and **modified** buildings

- Buildings in the 3D model but not in the 3D point cloud
- Buildings in the 3D point cloud but not in the 3D model
- Buildings with a wrong digital footprint in the 3D model or cadastre
- Buildings with structural changes (e.g., regarding the volume)



Case Study Berlin – Results

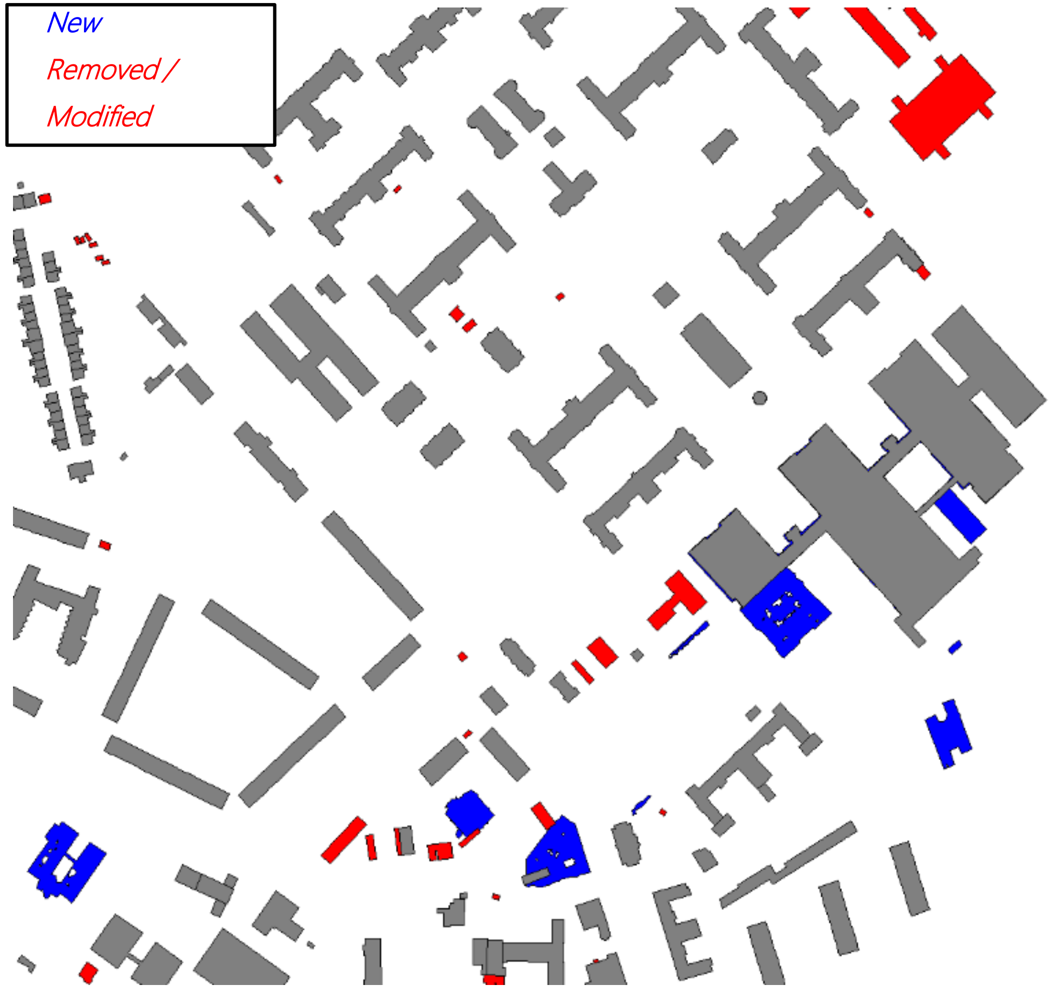


Comparison of buildings in the old and new 3D city model.

Case Study Berlin – Results

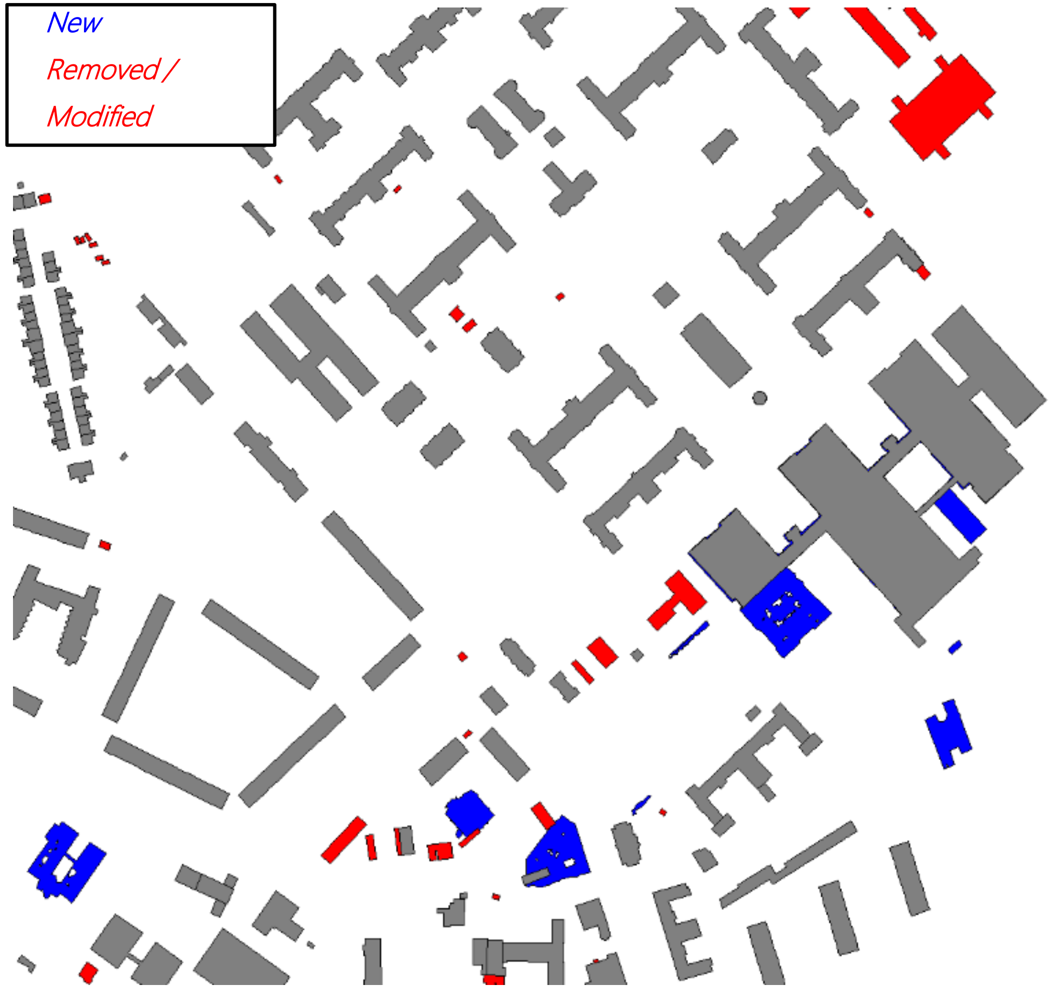
Comparison of buildings in the old and new 3D city model.

Case Study Berlin – Results



Comparison of buildings in the old and new 3D city model.

Case Study Berlin – Results



Comparison of buildings in the old and new 3D city model.

Case Study Berlin – Tree Detection

- Vegetation is important for the appearance of 3D city models
- Official tree cadastres do not cover the entire area of a city
- Trees for backyards, parks, and forests are missing

3D city model of Berlin with tree models based on a tree cadastre.

Case Study Berlin – Tree Detection

- Detection of individual trees in the 3D point cloud
- Derivation of tree properties (e.g., size, volume, and color)
- Real-time visualization of trees

Conclusions

“The presented processing and analysis techniques for 3D point clouds allow to detect, categorize, and quantify changes for buildings, vegetation, and ground surfaces.”

Classification of 3D point clouds is important for domain-specific applications.

Change detection enables selective updates.

GPU-based algorithms and **out-of-core processing strategies** are required to handle massive, dense, and large-scale point clouds.

Current development and research focus:

- Service-oriented infrastructure for processing 3D point clouds
- Database for 3D point clouds (e.g, Oracle Spatial Database 12c)
- High-performance hardware (e.g, Oracle Exadata)

Partner

HPI Hasso Plattner Institut

Supported by:

Bundesministerium für Bildung und Forschung

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be Berlin

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- Hasso Plattner Institute: www.hpi3d.de
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