City of Vienna | Surveying and Mapping

OGD Data Kappazunder

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Subject: OGD Data – Kappazunder Epoch 2020

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1 Introduction

Dear User,

We are pleased that you are interested in the geodata of the City of Vienna and thus generate added value!

Kappazunder is an innovative data source of the city of Vienna, which represents a digital image of the public space. Often such data (images and point clouds) are already referred to as a simplified form of a Digital Twin. In the case of the city of Vienna, however, these data are not seen as a digital twin, but are geodata from the field of surveying and geoinformation, which carry a wide range of information, and can also be input for a digital twin. The data is suitable for many applications such as visualization, artificial intelligence, surveying, simulation, preservation of evidence and many more. The data was collected as part of the Wien gibt Raum project.

https://digitales.wien.gv.at/en/projekt/wien-gibt-raum-vienna-provides-space/

In the following, detailed information on the data formats and the contents of the OGD test data set Kappazunder 2020 is given.

We wish you good luck for your projects using high-end geodata of the City of Vienna!

Best regards,

Department of Surveying and Mapping (MA 41)

Stadt Wien

2 Description of Kappazunder Geodata

Below is a description of the delivered Geodata Kappazunder, describing the following:

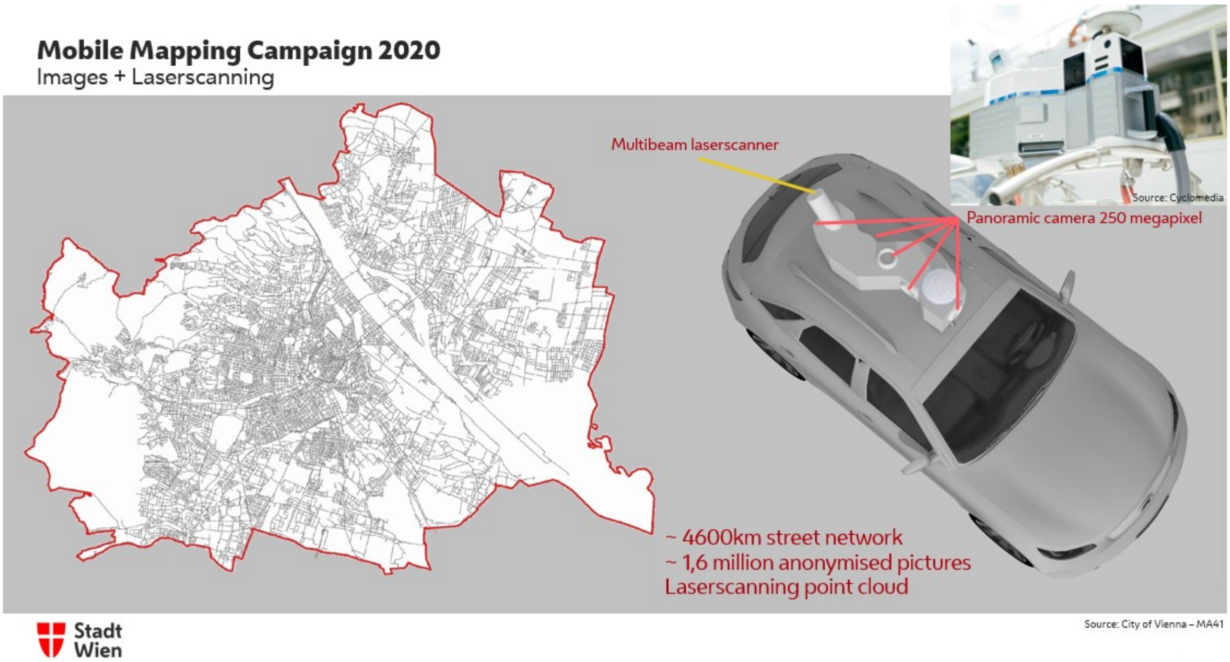
- Delivered Geodata
- Data interface Kappazunder

2.1 Provided Geodaten

The test data set Kappazunder (epoch 2020, raw data level 1) is delivered in the data interface Kappazunder (see item 3). Note: Kappazunder, by the way, is deliberately spelled with double P to honor the photogrammetric rotation angle Kappa.

The Geodata was collected during a vehicle-based mobile mapping campaign in 2020 and includes geodetically located image data, point clouds, associated navigation information (trajectory), and spatial orientations. Geodetic means that the location of the Geodata are, in most cases, georeferenced with a deviation from the reference of less than 10 centimeters. The image data with an image distance of about three meters were collected by a survey car while driving at the regulated traffic speeds. In addition to the images, the laser scanning system scanned the surrounding area with a range of up to 50 meters with an accuracy of a few centimeters. The geodata refer to a trajectory determined by a high-frequency measurement with an inertial unit (acceleration sensors).

In total, over 4600 kilometers were traversed, comprehensively digitizing Vienna with over one million anonymized images and a dense point cloud.



Note: There are already several publications on the topic of Kappazunder and the mobile mapping data that may be of interest to you: Link1, Link2, Link3, Link4

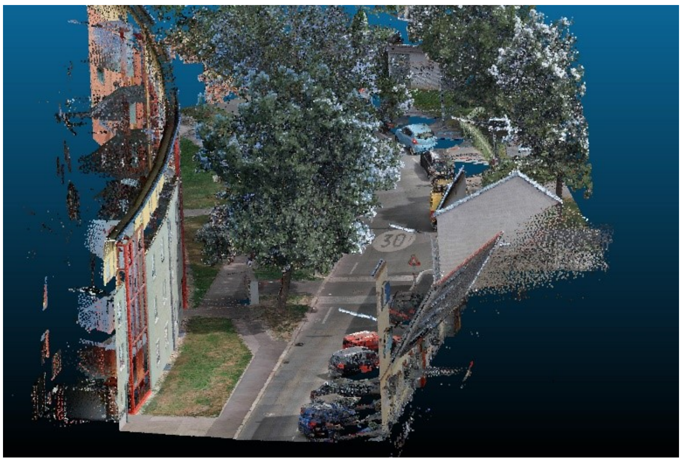
2.2 Spatial extent – test area

The test area is located near Wiener Gasse in Floridsdorf and shows a subset of the Kappazunder data (red line = image positions):

Top: area of the test data

Left: Top view of the point cloud clipped with 50m distance

Bottom: Rendering of a section of the LIDAR point cloud



All Geodata are delivered in the data interface Kappazunder (Siehe Kapitel 3). This represents a data interface in which the data is clearly structured and stored in open data formats.

Roughly summarized, there are the following categories:

- Trajectory
  - ASCII format according to Tabelle 1
- Image data (camera system: DCR11 250MPx)
  - Equalized image data for each trigger location (=panorama locations) and sensor as compressed image file (format jpg) as cubemap
  - Information about the inner orientation according to Tabelle 2
  - Information of the multi-sensor systems according to Tabelle 3
  - Information about the outer orientation according to Tabelle 4
- Point clouds (obtained by laser scanning. Scanner: Velodyne HDL-32E)
  - Sensor point cloud: point cloud files associated with trajectories. A trajectory can contain multiple scan files. Only First Echoes. Intensity and RGB values are included. (Format laz) - See Tabelle 5.
  - Information about the scan files according to Tabelle 6.
- GIS data
  - Shapefile of the panoramic locations
  - Shapefile of the trajectory
  - Shapefile of the scan areas

Notes:

- The data format may change for future Kappazunder epochs!
- The data has been anonymized according to the current state of the art.

3 Data interface Kappazunder

3.1 Folder structure

The data is delivered in the following folder structure:

LosID *(Logical unit in which the area of Vienna was divided)*

- Bild-Rohdaten *(Here are the images of the cubemaps, assigned by trajectory and sensor)*
  - Trajektorie_[traj_id] *(Number of the trajectory - Multiple folders possible)*
    - Sensor_[sens_id] *(Camera number - Multiple zip files possible)*
      - image_name.jpg *(Image name - Multiple files possible)*
- Bild-Meta *(Here is the information about the camera systems and image data)*
  - interior_orientation.txt *(Interior orientation of the camera systems)*
  - multisys.txt *(Definition of the interaction of multiple camera systems)*
  - image_meta.txt *(Orientations and positions of the cubemaps images)*
- Scan-Punktwolken *(Here are the scans, assigned by trajectory and sensor)*
  - Trajektorie_[traj_id] *(Number of the trajectory - Multiple folders possible)*
    - Sensor_[sens_id] *(Number of the scanner - Multiple zip files possible)*
      - scandata_[id].laz *(Scan name - Multiple files possible)*
- Scan-Meta *(Here is the information about the scanners and point clouds)*
  - scan_meta.txt *(Positions of the scans)*
- Verortung *(Here is the information on trajectory and sensor offset)*
  - Trajektorien
    - trajectory_[traj_id]_[gpsweek]_[epsg].zip *(Number of the trajectory with the measurement data of the inertial unit)*

3.2 Location of the traversing data - trajectory

The trajectory describes the position and orientation of the survey platform (body frame) in the global reference system.

The recording trajectory is described by the following parameters:

Epoche [GPS-Time]	GPS time in seconds from last Sunday. The corresponding GPS week is included in the file name.
$\mathbf{X}_{glob} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{glob}$	Position of the survey platform (INS reference point) in the global reference system. An identification of the used global reference system is given in the file name as EPSG code (acc. to https://epsg.io).
$\mathbf{R}_{body}^{glob}(rx, ry, rz)$	Description of the orientation of the survey platform (INS reference system) in the global reference system by the three Euler angles rx, ry, rz.

$m_X, m_Y, m_Z, m_{rx}, m_{ry}, m_{rz}$ Standard deviation of the corresponding parameters

- The **trajectory** is described by means of the following text file and is provided in compressed form [*trajectory_[traj_id]_[gpsweek]_[epsg].zip*]:

Tabelle 1: Data format of the trajectory

Epoche [GPS-Time]	X [m]	Y [m]	Z [m]	rx [rad]	ry [rad]	rz [rad]	m_X [m]	m_Y [m]	m_Z [m]	m_{rx} [rad]	m_{ry} [rad]	m_{rz} [rad]
double	double	double	double	float	float	float	float	float	float	float	float	float
…	…	…	…	…	…	…	…	…	…	…	…	…
n Epochs of the Trajectory												

The information about the definition of the INS reference system and the parameterization of the rotation matrix can be found in chapter 3.3.4.

3.3 Image data

3.3.1 Image raw data

The individual images are stored in the image data format JPEG as multi-sensor system Cubemap. The six cube faces are stored as sensors in separate zip files (see also **Fehler! Verweisquelle konnte nicht gefunden werden.**).

3.3.2 Interior orientation

For the recorded image data, the geometric camera imaging model is known. Any distortion errors as well as the correction of the image main point were carried out in advance.

The following additional parameters are described:

c Chamber constant (focal length)

ps_u, ps_v Pixel size of the sensor horizontal/vertical in mm

pix_u, pix_v Image dimensions in pixels

In addition, the following approximate parameters are specified:

Δh	Height of the sensor above the road surface (accuracy 5cm)
$pitch$	Inclination of the sensor with respect to the road surface (accuracy 5°)

The geometric mapping model is described by the following text file [*interior_orientation.txt*]:

Tabelle 2: Data format of the geometric mapping model

Sensor id	Typ Abb.	c [mm]	ps_u [mm]	ps_v [mm]	pix_u	pix_v	Δh [m]	$pitch$ [rad]
int	[p, a]	float	float	float	int	int	float	float
…	…	…	…	…	…	…	…	…
n image sensors								

Explanation Value range: p - perspective, a - equidistant

3.3.3 Additional information multi-sensor system

Since the camera system was realized by a panoramic camera, the individual sensors are defined as a multi-sensor system. These are single images, which together form a cubemap. The multisensor system is described via the following text file (*multisys.txt*):

Tabelle 3: Data format for the definition of multi-sensor systems

Multisens System id	Type	Referenzsensor id	Sensor id	…	n Sensoren
int	[m, s]	Int	int	int	int
…	…	…	…	…	…
n multi-sensor-systems					

Explanation Value range: m - multihead, s - stereo system

A multi-head system is understood to mean the following:

CubeMaps (virtual multihead system) consisting of six perspective single images.
Note: The given precise relative orientation between the individual sensor heads of the multi-sensor system can be derived from the exterior orientations.

3.3.4 Bild-Metainformation (Exterior orientation)

In order that the images can be located via the acquisition trajectory, the necessary meta information for each image to be processed is described with the following text file [*image_meta.txt*].

The image position is described by the following parameters:

Epoch [GPS-Time] — GPS time in seconds from last Sunday.

$\mathbf{X}_{glob} = \begin{bmatrix} X \\ Y \\ Z \end{bmatrix}_{glob}$ — Position of the sensor (camera projection center) in the global reference system. The identical global reference system must be used as for the trajectory.

$\mathbf{R}_{sen}^{glob}(rx, ry, rz)$ — Description of the orientation of the sensor (sensor coordinate system) in the global reference system by the three Euler angles rx, ry, rz.

Tabelle 4: Data format for the assignment of the processed images

Traj. id	Sensor id	Image id	Epoche [GPS-Time]	image_ name	X [m]	Y [m]	Z [m]	rx [rad]	ry [rad]	rz [rad]
int	int	float	double	string	double	double	double	double	float	float
…	…	…	…	…	…	…	…	…	…	…
n images										

- The parameterization of the rotation matrix $\mathbf{R}_{sen}^{glob}$ and the definition of the sensor coordinate system (INS reference point) is as follows for the 2020 data epoch:

$$\boldsymbol{R}_{sen}^{glob}(rx, ry, rz) = R_{rot_z} * R_{rot_x} * R_{rot_y}$$

rz "yaw" $$R_{rot_z} = \begin{bmatrix} \cos rz & \sin rz & 0 \\ -\sin rz & \cos rz & 0 \\ 0 & 0 & 1 \end{bmatrix}$$

rx "pitch" $$R_{rot_x} = \begin{bmatrix} 1 & 0 & 0 \\ 0 & \cos rx & -\sin rx \\ 0 & \sin rx & \cos rx \end{bmatrix}$$

ry "roll" $$R_{rot_y} = \begin{bmatrix} \cos ry & 0 & \sin ry \\ 0 & 1 & 0 \\ -\sin ry\, 0 & 0 & 1 \cos ry \end{bmatrix}$$

Note: The positive angle rz (yaw) is defined from north to east (clockwise)

Rotations from the sensor to the terrain:

$$V_{Terrain\,(Global)} = \boldsymbol{R}_{sen}^{glob}(rx, ry, rz) * \boldsymbol{V}_{Sensor} = R_{rot_z} * R_{rot_x} * R_{rot_y} * \boldsymbol{V}_{Sensor}$$

The center of the coordinate system is located in the center of the inertial measurement unit (IMU):

- X-direction of the IMU: Positive in the direction of the right side of the vehicle
- Y-direction of the IMU: Positive in the direction of travel
- Z-direction of the IMU: Positive in the direction of the zenith

3.4 Laser scan data

3.4.1 Point clouds

Point clouds from laser scans are stored in LAZ format (zipped LAS variant) Version 1.4 Point Data Record 7 (http://www.asprs.org/wp-content/uploads/2019/03/LAS_1_4_r14.pdf). The following information is provided:

Public Header Block: Mandatory fields
Point Data Records: Point Data Record Format 7, with the following fields

Tabelle 5: Listing of the Point Data Records for the delivery of the point cloud

Name	Format	Size	Available
X	Long	4 bytes	Yes
Y	Long	4 bytes	Yes
Z	Long	4 bytes	Yes
Intensity	Unsigned short	2 bytes	Yes
Return Number	4 bits (bits 0-3)	4 bits	Yes
Number of Returns (Given Pulse)	4 bits (bits 4-7)	4 bits	Yes
Scan Direction Flag	1 bit (bit 6)	1 bit	Yes
Scan Angle	short	2 bytes	Yes
Point Source ID	unsigned short	2 bytes	Yes, Must match the associated trajectory ID.
GPS Time	double	8 bytes	Yes, GPS time in seconds from last Sunday.
Red	unsigned short	2 bytes	Yes
Green	unsigned short	2 bytes	Yes
Blue	unsigned short	2 bytes	Yes

Please note, that only first echoes are stored in the point cloud. The point clouds are cut off at a range of 50 meters. The point cloud may contain wrong measurements due to moving objects.

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3.4.2 Scan-Metainformation

The following scan metadata information is used to assign the corresponding data files to the individual trajectories and must be described with the following ASCII file [*scan_meta.txt*].

Tabelle 6: Data format for the announcement of the scan meta information

Traj. id	Sensor id	data file id	Epoche start [GPS-Time]	Epoche end [GPS-Time]	scandata_name
int	int	int	double	double	string
…	…	…	…	…	…
n Data files					