Workshop at the AAL Forum 2014

Bringing Together Indoor and Outdoor Mobility Solutions: Methodological Approaches for Navigation, Localization, and Environment Modelling

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Elevating Map Data to the 3rd Dimension

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Abstract — Typically map data is only available in two dimensions. It is sufficient to know where one is on the surface of the globe. Knowing where one is located allows for determination of the height; but only if one knows the ground model in three dimensions. Then the height can be extracted out of this model. Knowing the height one knows whether he is walking under or over the bridge.
Indoors it is essential to know the third dimension. Because in buildings there naturally is a choice of floors where one can be located. A navigation system therefore needs information about the third dimension to guide a user to the desired location.
For reasons of reliability of map data in iWalkActive mainly commercial data is used. As a disadvantage there is not a global coverage, only data of parts of areas have been bought; due to costs. To allow for navigation in larger areas commercial map data is complemented by open source data.
In this presentation it is shown how the map material suited for navigation is combined with the height model in the AAL-JP project iWalkActive. Additionally the combination of commercial and open source data will be shown.

I. INTRODUCTION

Some time ago I wanted to walk from Stansstad to Hergiswil, two small villages in the heart of Switzerland (https://www.openstreetmap.ch/?zoom=16&lat=46.9797&lon=8.32301&layers=B00T). There are several transport axes crossing Lake Lucerne: local railway, local road and a quite important highway connecting Northern Europe with Southern Europe. So I asked OSMAnd to navigate me (**Figure 1**).

Figure 1 Route calculated by OSMAnd and the real situation

While walking over the bridge I stopped to enjoy the view to the lake and the mountains. After the stop OSMAnd directed me to turn left. But there was no possibility to walk on the indicated path, because there is no path! (**Figure 2**)

Figure 2 New route calculated by OSMAnd and the real situation

I noticed another path crossing below the bridge, about 5m below. As I did not have a bungee jumping rope with me I decided to follow the initially proposed track. And – by the way – I really don't like bungee jumping. (**Figure 3**)

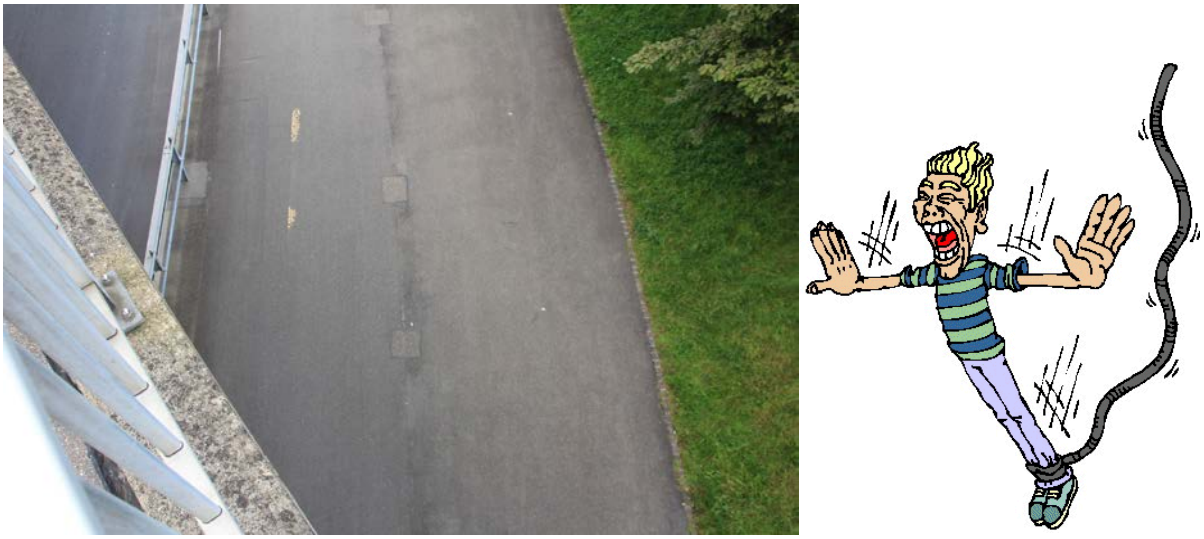

Figure 3 The alternative path situated 5m below the actual path

In this talk I will speak about the limitation of a 2D map representation. In the project iWalkActive we found that users of a walking aid need precise data of their position, including the height information. The solution in iWalkActive will be outlined.

II. iWalkActive Consortium

The iWalkActive consortium is composed of 9 partners from 3 countries:

- Lucerne University of Applied Sciences and Arts, iHomeLab (CH)
- AIT Austrian Institute of Technology GmbH (AT)
- CareGuide GmbH (CH)
- TRIKON Solutions AG (CH)
- Geo7 AG (CH)
- ITH icoserve technology for healthcare GmbH (AT)
- Social Services Department of the Kanton Zug (CH)
- Trionic Sverige AB (SE)
- SPF – Sveriges Pensionärsförbund (SE)

The project is coordinated by Lucerne University of Applied Sciences and Arts, iHomeLab. The iHomeLab is a think tank and research center for building intelligence (http://www.ihomelab.ch).

More information on the project can be found on http://www.iwalkactive.eu.

III. NEED FOR HEIGHT INFORMATION

Indoors we are used to think in three dimensions. If we enter a building we intuitively decide on the floor we want to reach. And the floor is the height information.
So knowing the 2D coordinates of the location of a person is not sufficient. It's essential whether one is on the 1st or 2nd floor (**Figure 4**).

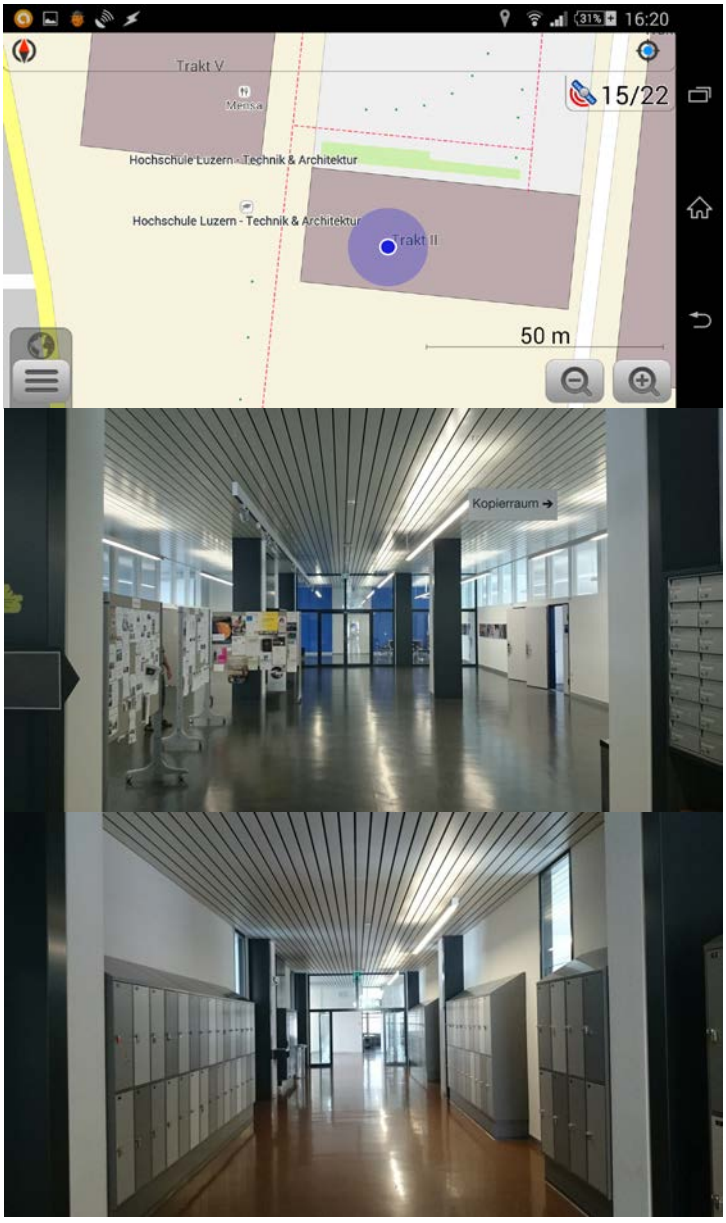

Figure 4 Indoors it's obvious that the 3rd dimension is needed

As a consequence paths inside a building have to be tagged with the height information. Also the transitions between floors – like stairways or elevators – have to be captured. This results in a 3 dimensional structure of the buildings paths like shown in **Figure 5**.

The paths including all additional information like width, impediments, inclination, surface and – of course – height has to be captured for every building in question. And as there is yet no general available data for buildings every building operator has to capture these data.

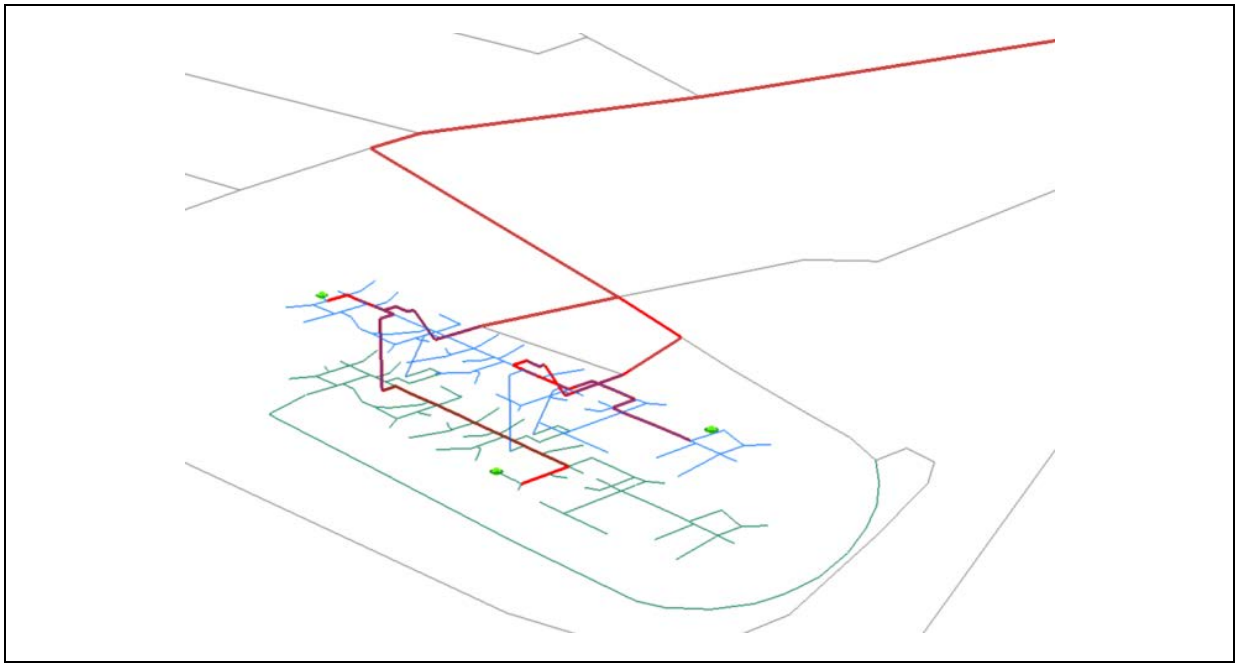

Figure 5 Representation of the 3 dimensional structure of a building with 2 floors

As we have seen in the example at the beginning also outdoors there is a need to know the height of a location. The mentioned situation is a bridge crossing other paths and roads (**Figure 6**). For outdoors map data exists for almost every area on earth. Even some information of the height might exist. But usually only the height of earth's surface at a specific location exists. The height of a path above the surface level is not known.

Figure 6 Situation of the bridge crossing a road and a path

Google Earth and Google Maps provide 3-dimensional views of the map data. Particularly in Google Earth it's obvious that the 3rd dimension isn't really of use. This can be seen when we look at the representation of the bridge (**Figure 7**). We remind: this is the main highway connection between Northern and Southern Europe. Google Maps shows a photo that is warped to get a 3D effect. Google Earth uses height information, but that of the earth's surface. This results in a representation that would prevent us definitely from using the highway.

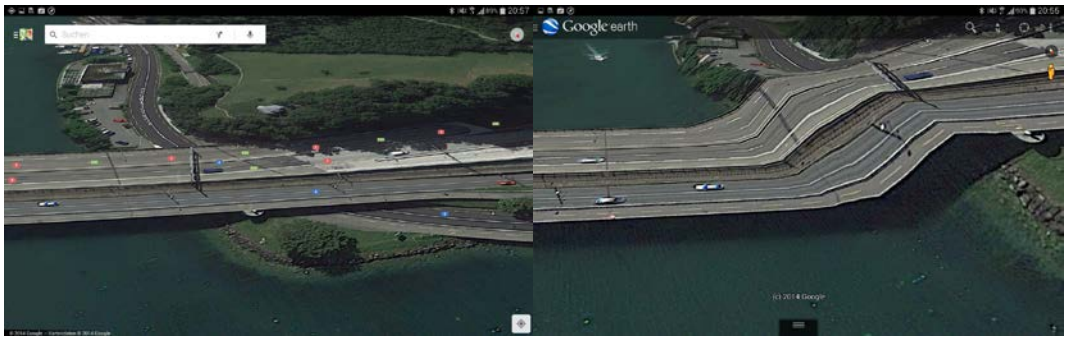

Figure 7 Google's 3D representation of the bridge crossing Lake Lucerne (Google Maps left, Google Earth right)

In iWalkActive we don't rely on Google's data. We use commercial and open map data combined with a digital height model (DHM) (**Figure 8**). We use Navteq and OpenStreetMap (OSM) as map data to find – for example – the coordinates of an address. With the coordinates we look for height information in the DHM. So it is possible to determine a 3 dimensional location.

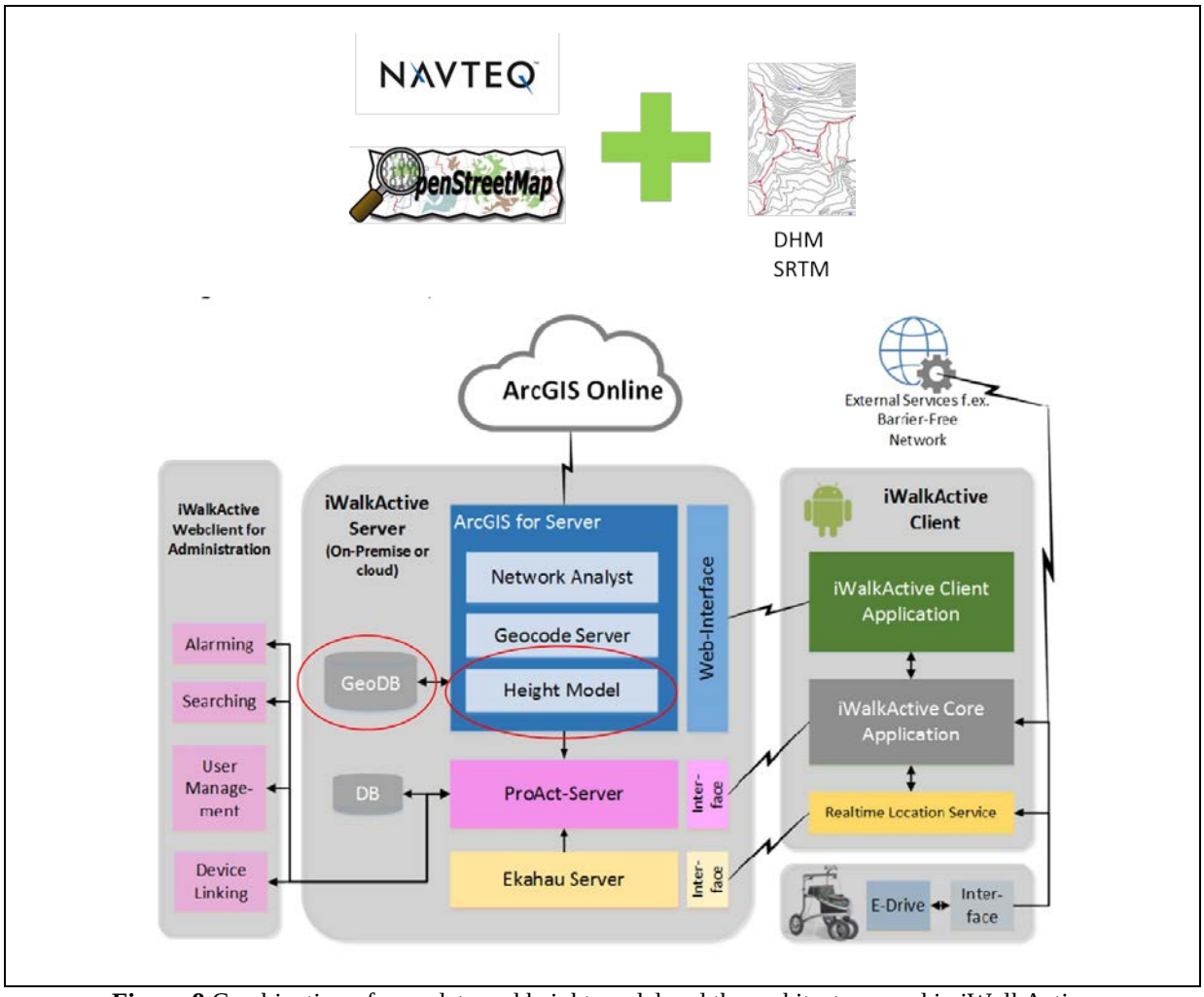

Figure 8 Combination of map data and height model and the architecture used in iWalkActive

Because of its commercial nature, at the moment Navteq is used only for smaller areas where we want a good coverage. For the other areas OSM is used. But it seems that more and more OSM is also suitable for areas in need of a good coverage.
For the height information we rely on data issued by local authorities. This data has an appropriate precision and resolution. The data typically is not free. Therefore this data is also used for smaller areas where a good coverage is needed. For the other areas freely available data from SRTM (Shuttle Rada Topography Mission) is used. In iWalkActive for example areas in Bern, Lucerne and Zug are planned to cover by commercial data (**Figure 9**).

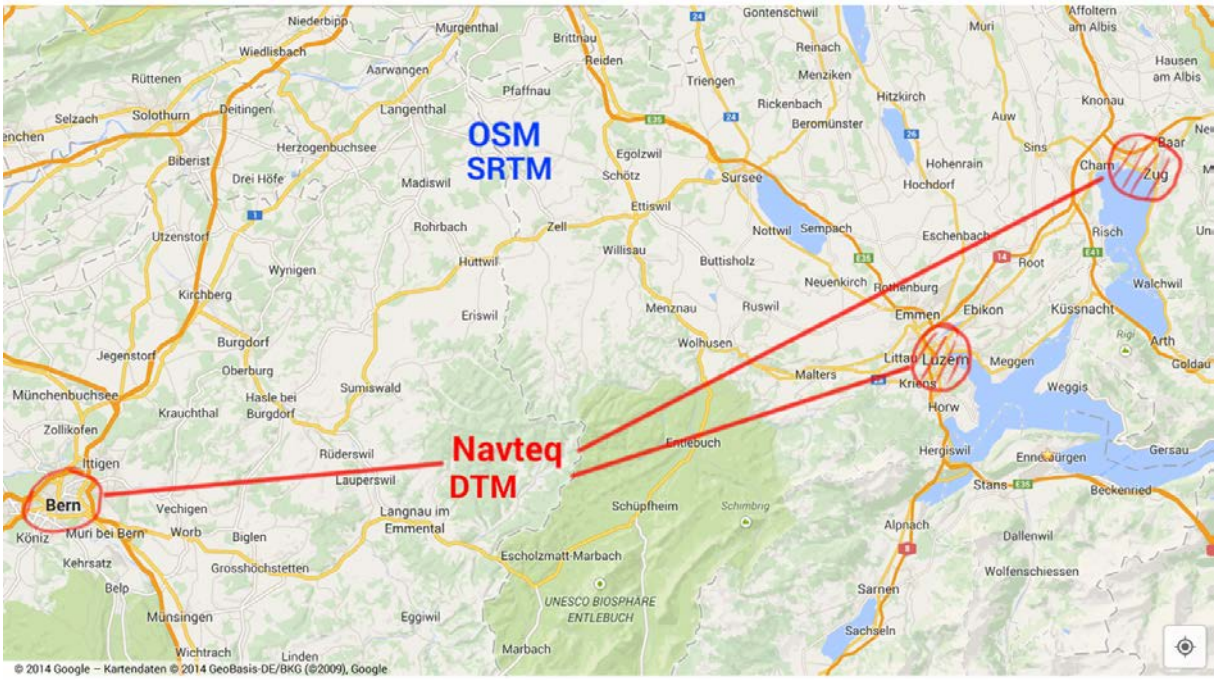

Figure 9 Use of commercial and freely available data for maps and height model

IV. GEOCODES

Geocodes – addresses or names of points of interest (POI) – must be transformed to coordinates. For outdoors 2D coordinates are adequate because there are seldom two addresses or POIs at the same place. For example there is only one hotel at one location. So the transformation between geocodes and 2D coordinates and vice versa is non-ambiguous (**Figure 10**).

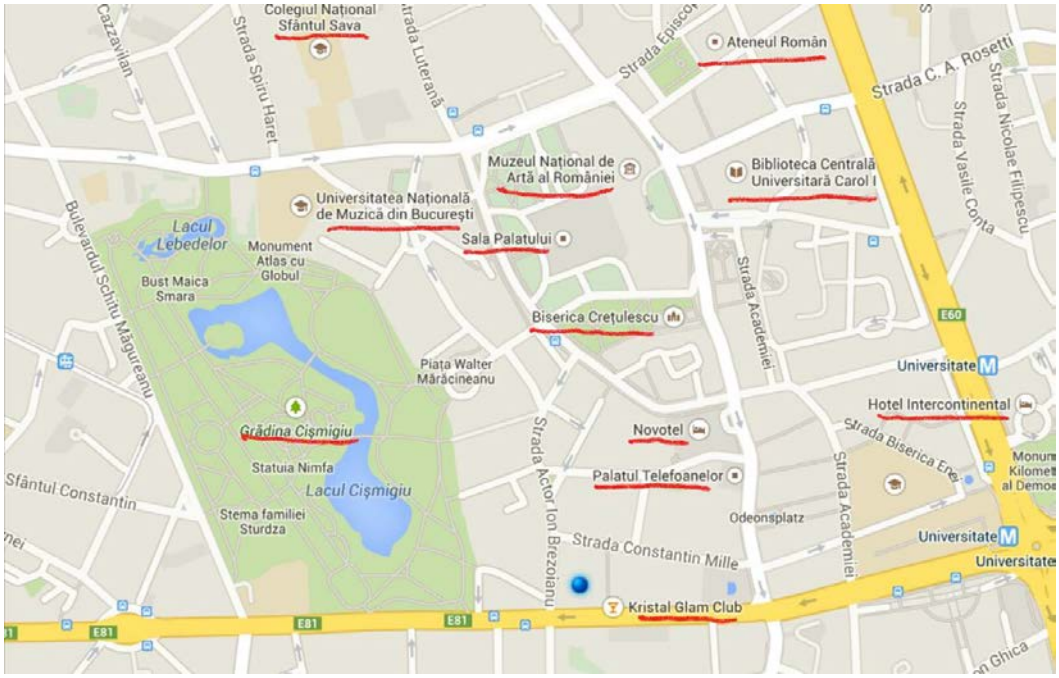

Figure 10 Transformation between geocodes and 2D coordinates and vv is non-ambiguous

Indoors the situation is different. Different locations in a building can have the same coordinates in 2D, like two offices situated on different floors. Therefore the transformation between geocodes and 2D coordinates can be ambiguous. The 3rd dimension – the height information – resolves this problem.

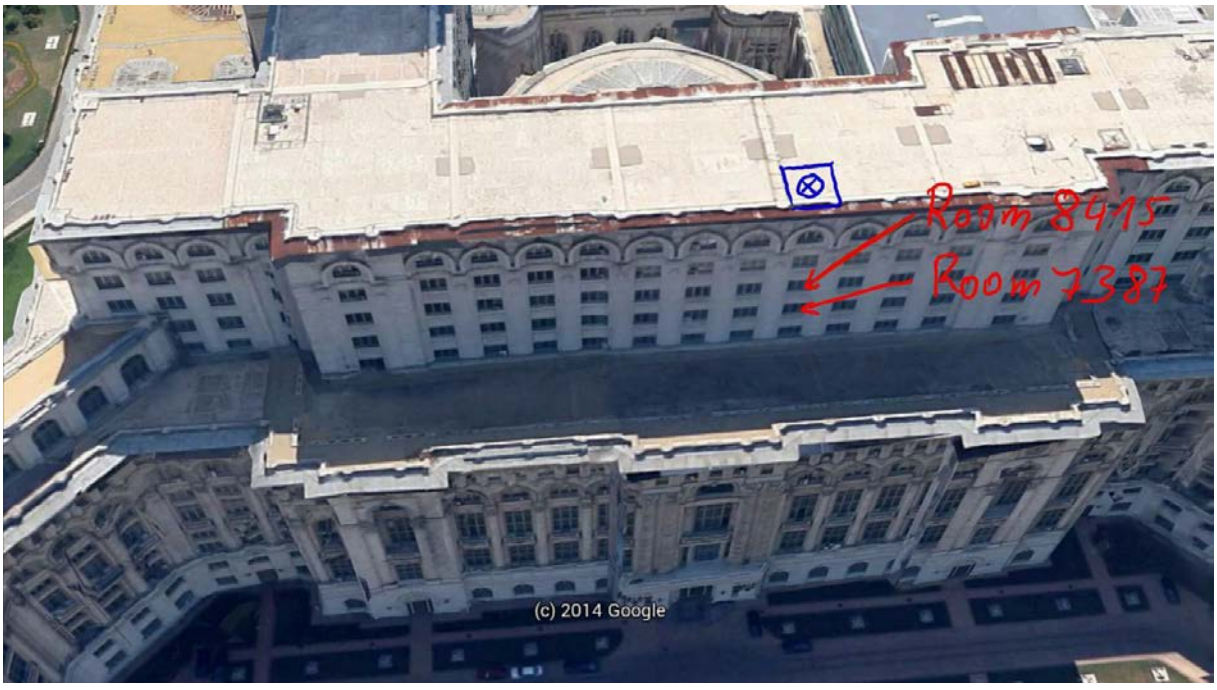

Figure 11 Typically indoors geocodes need the height information

V. PROCESS

Following the process of capturing particularly the indoor data is described.

- Acquisition of the indoor map information of the building(s)
- Survey of existing indoor WiFi-network; the distribution of WLAN emitters should comply the requirements of Ekahau
- Capture of indoor routes, geocode names, points of interest (POIs) as the base for the geo-location service
- In this context the inclusion of the information about the restrictions on mobility with the rollator (for example stairs) of the concerned site is needed
- Calculation of 3D-coordinates of the respective area with the help of the height model information
- Transformation and embedding of the indoor-map or preferably already available digital geometric and attribute information into the outdoor world (WGS84)
- Extension of the NAVTEQ data model by the indoor data
- Creation and deployment of services according to the needs

VI. ACKNOWLEDGEMENT

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