Photogrammetry and 3D Car Navigation

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ABSTRACT

The technological development of recent hardware systems of car navigation systems allows the real time computation of 3D models of digital terrain models including buildings and Streets. Unavailability of a European database with 3D content decelerated the progress in this area. In consideration of the given business possibilities, establish for this industrial sector, is the request of new, more efficient and reasonable data acquisition methods is fully justified. This article generally describes the development of data acquisition technologies and the experience with 3D models at Harman Becker.

1. ADVANCE DEVELOPMENT

Harman Becker Automotive Systems - innovative systems GmbH (HBAS), is one of first Provider of car navigation systems worldwide and leading in the quality and innovation.

The decision to implement the 3D content into our navigation system was made already back at the end of the nineties.

Back then a 3D research and the development team was created, with the task to implement the 3D-data into a car navigation systems. At that time, it was obviously known that in the near future the hardware capability would allow such representation of whole city models displayed in car navigation systems

1.1. Availability of 3D data

The analyses of existing 3D-data coverage and data acquisition technologies were initially disillusioning. There were neither coverage of city models nor a sufficient quality of digital terrain models for use in car navigation systems.
Date were suitable for overview models only. On the other hand, for all involved parties it was definitely clear, which potential and benefits for the end customers has this 3D representation on a navigation system. Instead of waiting for progress on 3D market content, HBAS decided to move forward by starting an own intensive development. There were two main areas of activity: The cooperation with communal data suppliers and research centers and the own production of 3D-Landmarks.

1.2. Government and City models

The cooperation with the German cities leading in manufacturing 3D models, was focused on the following two goals: on one side the exploration of existing 3D data: their quality formats and structures, on the other hand, the feasibility studies and development of 3D-Prototyps based on delivered models. The results were analyzed together with involved parties of government measurement authorities.

Preliminary result already proofed that the data from these authorities were qualified for the production of 3D navigation, even with the limit of different data formats and contents. Additional challenge was different kind of generalization, data design and not standardized content in Germany. From users point of view, it is obligatory, to work with specified, and consistent models. The situation in others EU-countries was much simpler. A central government data supplier and one responsible distributor of that data are in fact preferred by a global player like HarmanBecker.

The further important experience was that the previous city models did not consider the geometry of streets: The are existing layers in city areas that describe outlines of streets (like “Hochbord”, “Tiefbord” layer), but these elements are not described as objects.

Promising for future use are the projects of data acquisition with the airborne laserscan – technology. This technology allows fast and reasonable data acquisition and conversion into 3D digital terrain models and 3D buildings (e.g. the recent 3D-project of federal state Bavaria) Test results of these 3D digital terrain models including 3D buildings fulfilled expectation on conformity and geometrical accuracy.

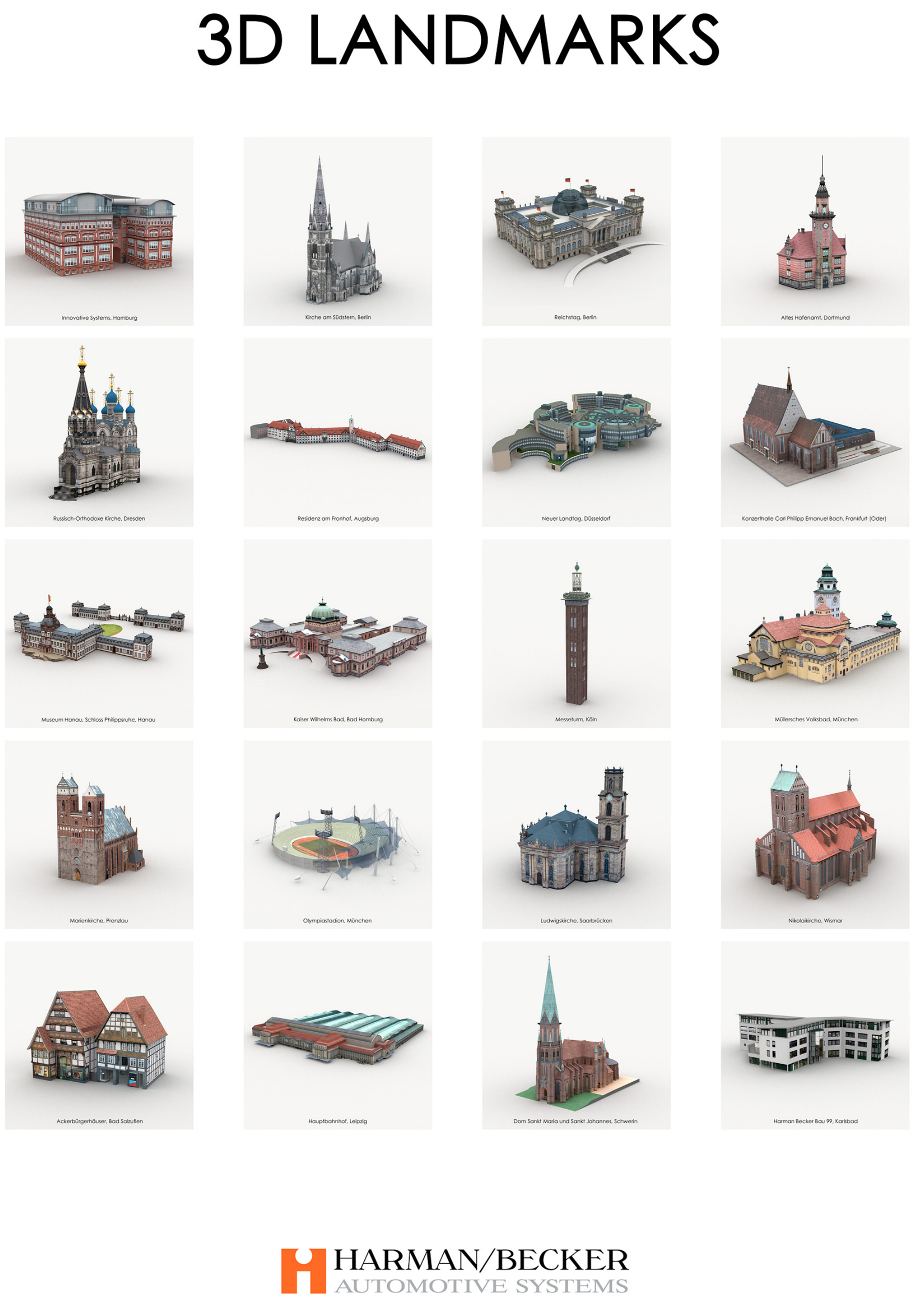
1.3. 3D Landmarks

Due to the fact in the year 2000 adequate data of 3D buildings was very rare, Harman/Becker started developing the concept of 3D-Landmarks.
A 3D-Landmark can be described as a generalized digital model of a prominent building, created using polygons and textures for its façades.

Fig. 1: Dome in Naumburg

HBAS elected the objects to be collected dependent on its historic-cultural relevance and its visibility in a cities silhouette.

Most of such buildings own a very complex geometry, hence modeling the 3D data on the basis of traditional photogrammetry was too costly. After several comparative tests the finally chosen acquisition method was the one that is based on terrestrial 3D-Laserscanning.
The three-dimensional data generated on operation of a laser scanner consists of (up to) several million single points in 3D space, which together reflect the shape of the scanned structure. This data is called the point cloud. Depending on resolution set for the scan, edges and surfaces of a building can be acquired accurate to few centimeters.
Additionally, digital photos get taken for the finer structures of the façade, preferably orthogonally.



The main part of the generation of a 3D-Landmark implies creating the polygonal model, based on the pointclouds shape. Afterwards, the geometry gets mapped with equalized and cleaned up photos (textures).
HBAS has examined several software packages from various branches, to evaluate the best possible workflow: Architecture (CAAD), Visualization, Photogrammetry, Engineering, Design and Film. Experimentally, buildings have been modeled using diverse methods and programs. After analyzing the results, HBAS realized that none of the tested applications was capable of giving the required efficiency. Furthermore, one fact has been very insightful: the amount of design steps leading to comparable results varied extremely from application to application.
Thus, Harman/Becker started designing proprietary software, while at the same time acquiring the big amount of raw data needed for the further steps of Landmark creation. The tools, which have been programmed, are able to detect similar edges of several pointclouds (more than one point cloud exists per building geometry), so the "registration" (fitting together) of the raw data could be achieved in an automatic manner. This is noteworthy, as the process got rid of the necessity of using DGPS to register the pointclouds.
Furthermore, the software tools are capable of creating simple shapes of geometry fitting to the template pointclouds, resulting in a skeletal structure for the detailed polygonal buildings to be modeled.
Further editing of the data has been achieved using 3D software available on the market, enhanced by proprietary add-ons needed for proper modeling and texture-placement.

The workflow that has been designed within one year has yielded to a considerably speedup of production and hence to a successful completion of the project "3D-Landmarks", in which 1500 3D models from all over Germany have been completed.

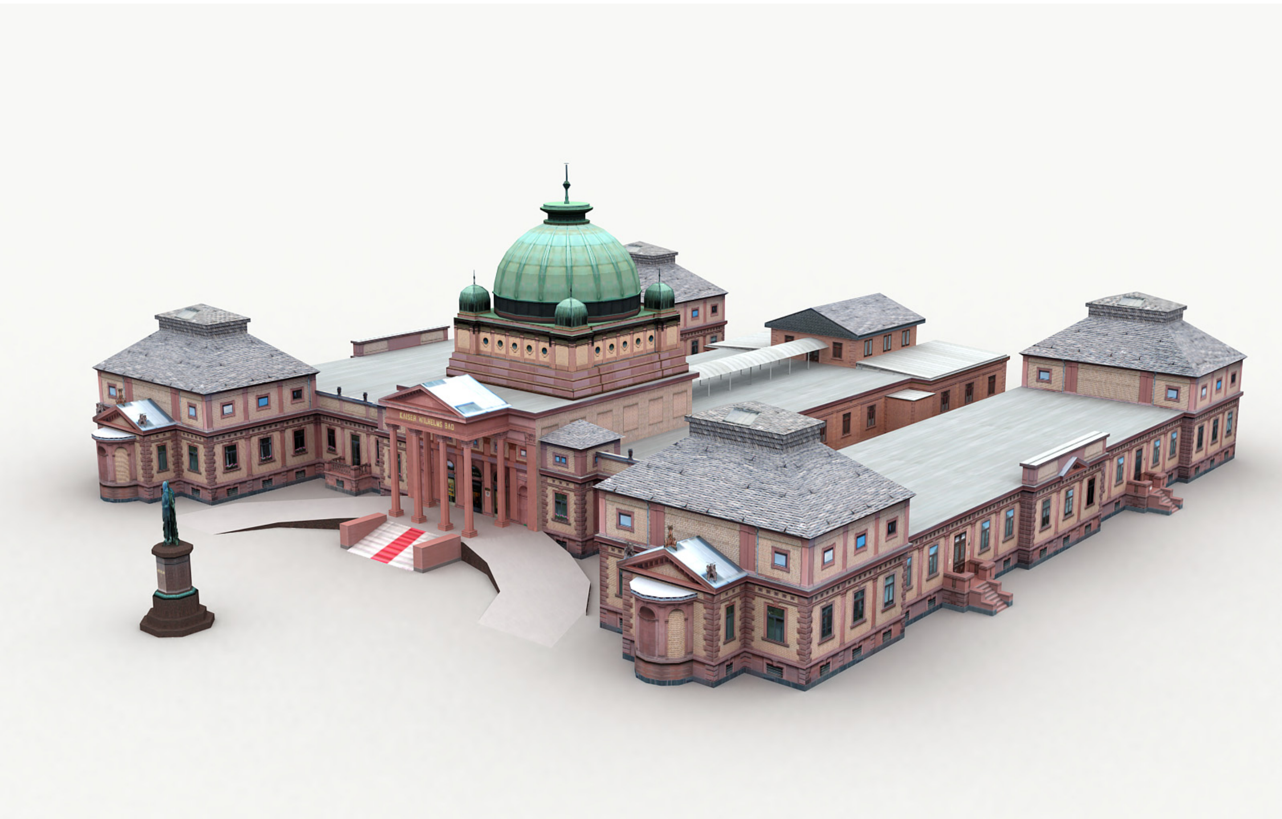


Fig. 2: Bad Homburg: Kaiser-Wilhelms-Bad

It has to be emphasized that the selected method of acquisition did practically never result in bad or wrong geometry. The fear of roof areas not being of satisfactory accuracy could not be confirmed. Merely for flat roofs completely hidden behind porches assumptions had to be taken. There were rare cases where aerial views had to be consulted in addition to the terrestrial measurements.

1.4. Between Photogrammetric Accuracy and Computer Games

A great deal was demanded on the Landmark modelers, relating to the big amount of existent data. The models should consist of only very low number of surfaces (polygons). This constriction was necessary because it allows faster performance on the display of car navigation systems.
Under this determining factor the basic conditions for the evaluating person were hard: On the one hand, the building should be modeled preferably precise based on the measurements, on the other hand the decision had to be made which building parts should be preferred against others.

The development of a specification doing justice to these aspects was difficult: concrete guidelines for dimensioning and prioritization of individual building parts could not be defined, due to the vast amount of possible combinations. At last, the resulting solution consisted of an all-embracing catalogue containing criteria for all sorts of example buildings.

A therewith associated paradigm shift has been another challenge: The practice of photogrammetry assumes a precise reproduction of the measurement result. But the logic of a generalized construction forces the modeler to create a simplification of the identified structures, based on parallelism, rectangularity and regular repeatability.
Till today the failure of that balancing act can be seen in the data of many vendors, which have begun to jump in the field of 3D building acquisition.

Fig. 3: Zollhof in Düsseldorf

Fig. 4: Church „Zum Heiligen Kreuz“ in Franfurt / Oder

1.5. Status Quo

The progress of hardware performance and 3D acquisition technology results in a significant reduction of production costs and an immense increase of data collection speed.

Nevertheless, up to now 3D City models including terrain and roads are hardly available on the market.

In spite of great achievements related to textured 3D city models, produced by many German cities themselves, there's no all-over-the-country-offer in sight, neither from municipalities nor from the government.

Over the last years, expectations on environmental 3D data have grown vastly (e.g. car industry, internet, Google applications, etc.), thus data acquisition more and more becomes a task of commercial suppliers.
It remains to be seen which data providers, commercial or commune, can sooner offer the desired content.