Automatic relocation of link related data in an updated road map

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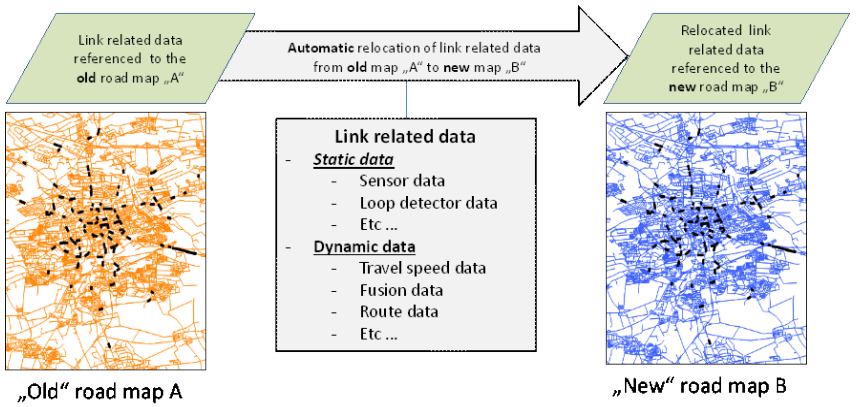
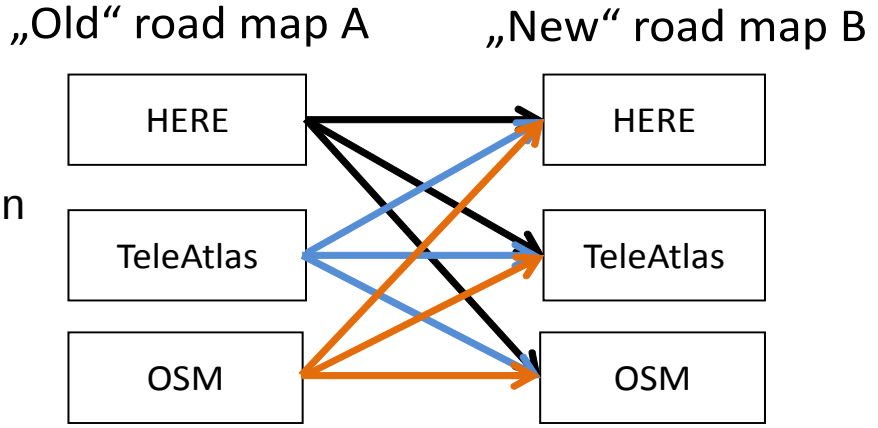
Objectives

- Problem:
  - for a rising number of Intelligent Transportation System (ITS) applications, location information obtained by the processing of sensor data is related to the links of a specific digital road map
  - relocation of any annotated location data,i.e. a proper mapping of these locations from the **old** to the **new** map becomes necessary

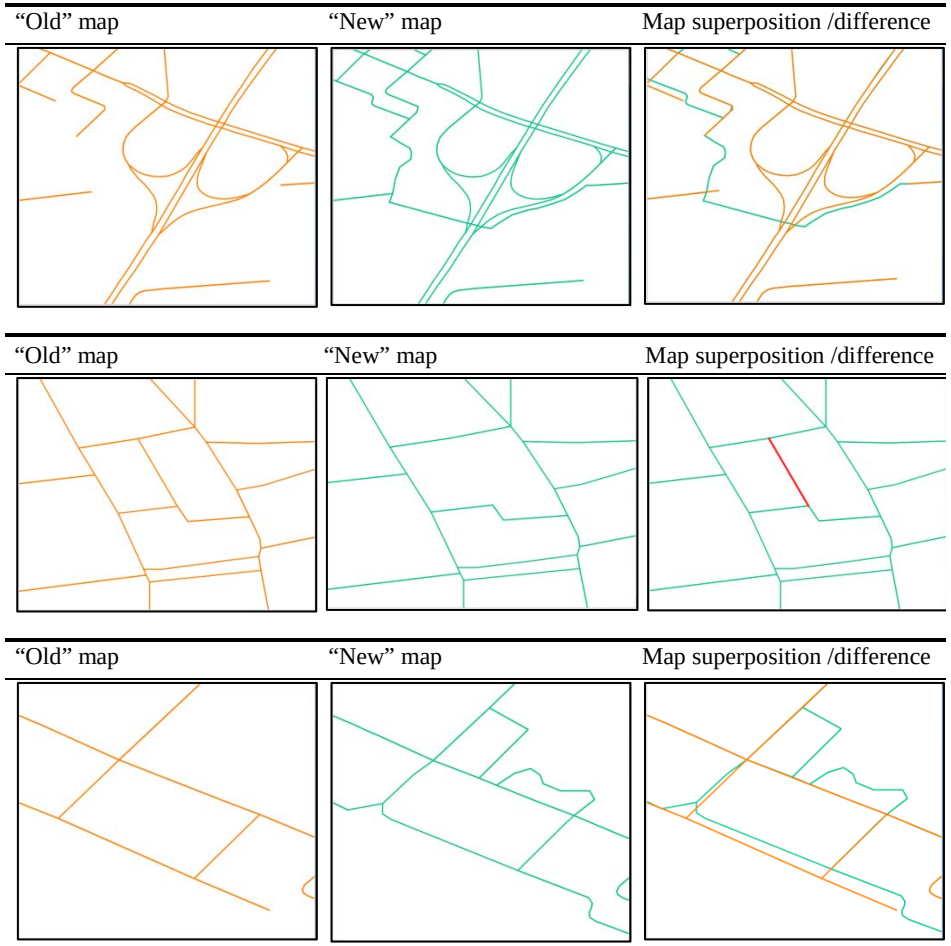


- Solution:
  - development of ITS software tools that alows the **automatic relocation** of location data between the two maps
  - Using the new tool, an almost fully automatic relocation is possible and thus the cost of service failures related to the map update can be avoided



Difference between old and new maps

- Case 1:
  - New links or edges are added in the „new“ map and are missing in the “old” map
- Case 2:
  - Links or edges that exist in the “old” map are missing in the “new” map:
- Case 3:
  - Availability of some links in “new” map with modified topology or geometry

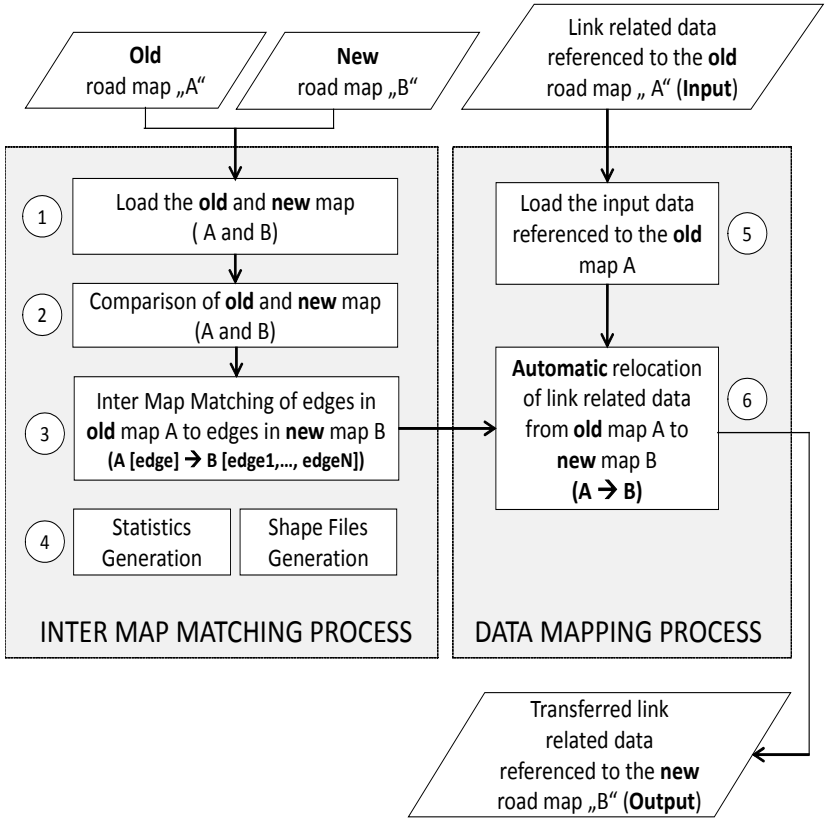


Static and dynamic location data

No	Data type	Data	Equipment / Processing unit	Description
1	Static data	Sensor data	- E.g. Bluetooth sensors	The geo-location of the sensor or detector is referenced on the link in the road map
2	Static data	Detector data	- Induction loops - Radars - Infrared detectors	
3	Static data	POI data	-	Point of Interest data as geo-location is referenced on a link in the given map
4	Dynamic data	Travel speed / time data	Processing unit	Travel speed /time information obtained for example from FCD or FOD is referenced on a link in a given road map
5	Dynamic data	Route data	Processing unit	The route information and the start and destination location are referenced on a link in a given road map
6	Dynamic data	Fusion data	Processing unit	The fusion data obtained from different sources is referenced on a link in a given road map
7	Dynamic data	Prediction data	Processing unit	Prediction data determined from different data sources is referenced on a link in a given road map

Workflow of the data processing

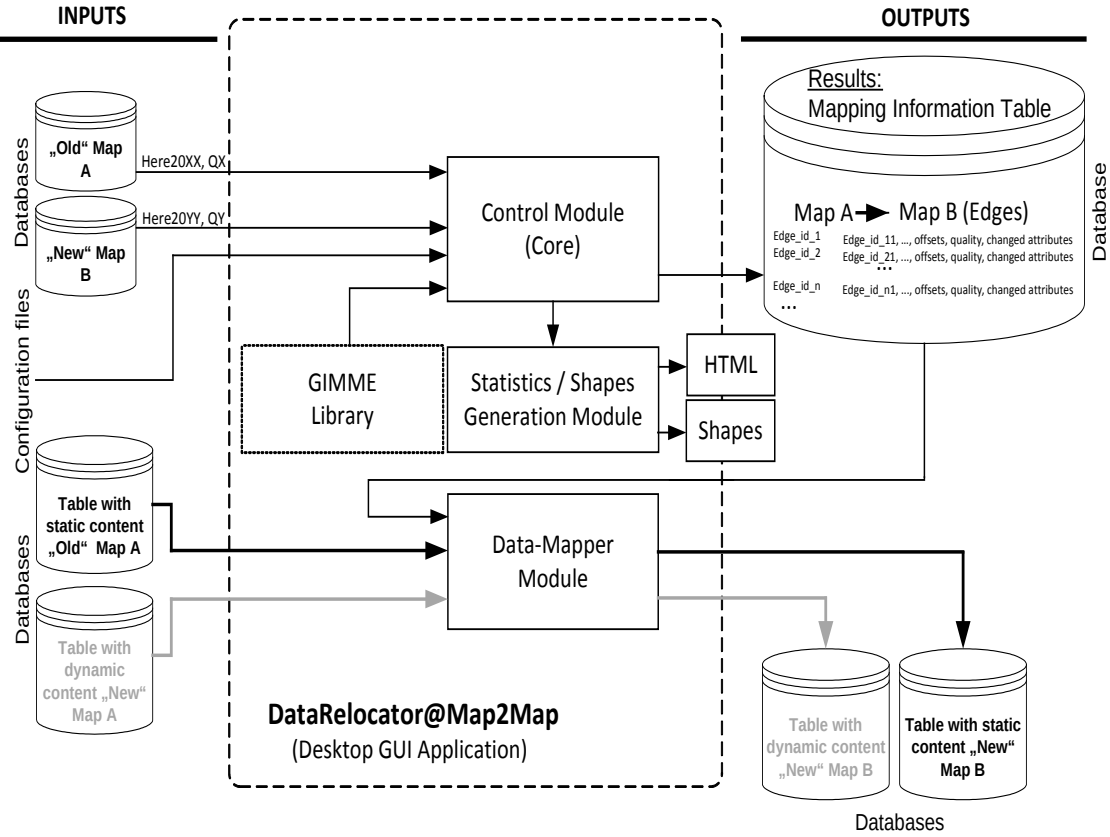
- Step 1: load “old” and “new” map from the database into the system
- Step 2: map comparison
  - *result consits of two lists of links in “old” map : IDENTICAL, NOT IDENTICAL*
- Step 3: inter map matching between “old” map and “new” map (map A → map B)
  - *For the IMM the geometry inter-map matching extension (GIMME) algorithm has been used. The **GIMME** algorithm has been described in detail in [5, 6]*
  - *IMM result consists of tree mapping lists: IDENTICAL, GIMME_POSITIVE, GIMME_NEGATIVE*
- Step 4: Statistics and shape files generation
- Step 5: Load the data related to the links of the “old” map as input data
- Step 6: Automatic relocation of link related data from the “old” map A to the “new” map B



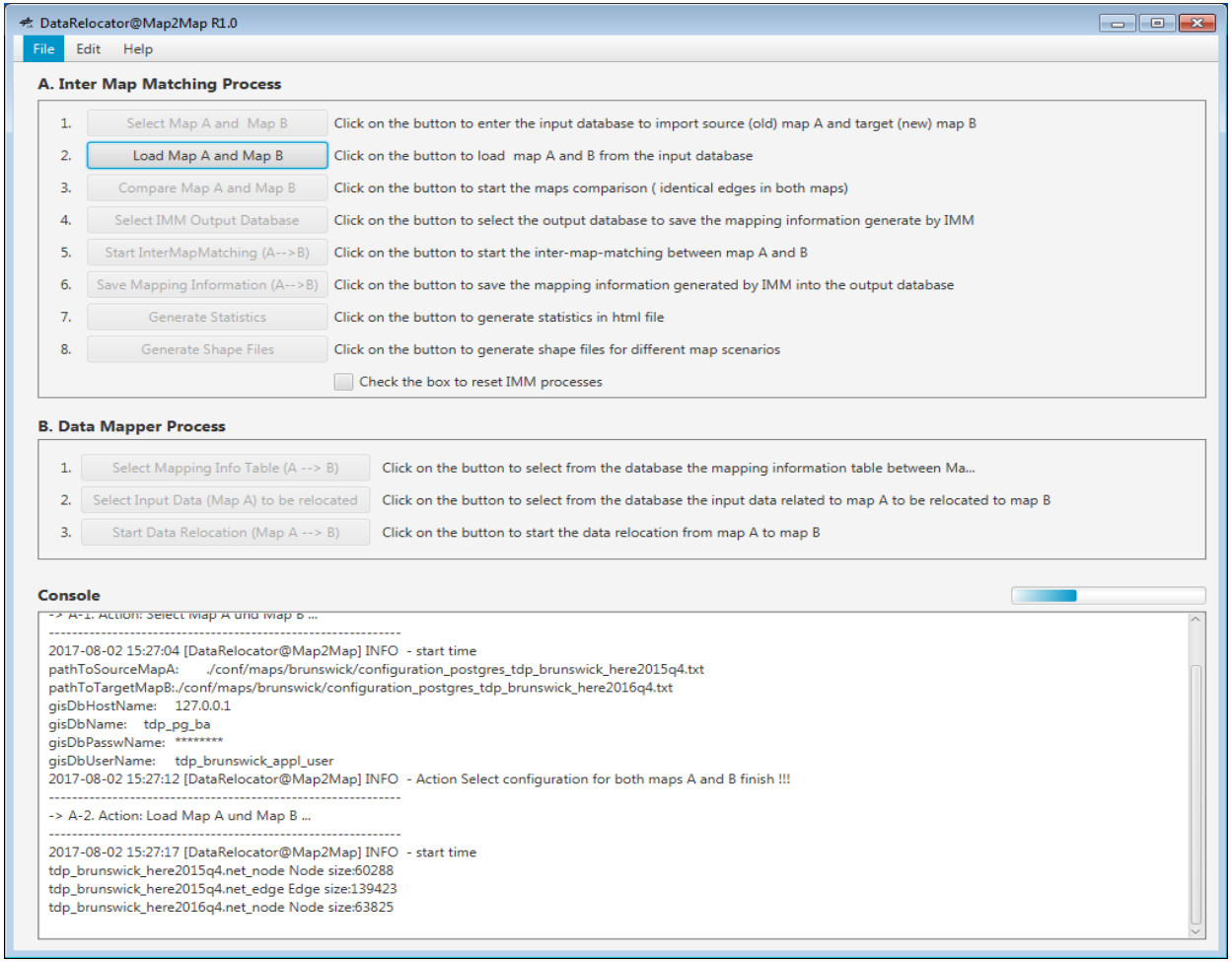
System architecture

The map *„Relocation"* tool consists of three main software components:

1. Data import components:
2. Processing units:
3. Data export components:



The Graphical User Interface (GUI)
DataRelocator@Map2Map Tool



Experimental results
Inter Map Matching (IMM)

- In order to demonstrate and to evaluate the newly realized map *relocation* tool
  - two digital maps from the city of Brunswick, Germany has been chosen.
  - two **HERE** digital maps from different release years 2015 and 2016
  - from different versions:
    - **2015q4** for the **“old”** map
    - **2016q4** for the **“new”** map.
  - a time lag of **one year** (2015 and 2016) between the two maps has been chosen.
  - the **“old”** map (source map) is from quarter **4** of 2015 while the **“new”** map is from quarter **4** of 2016.

Map	Total number of edges	Total sum of edge lengths in [km]
(Old) Brunswick Here2015q4	139.423	18.927,614
(New) Brunswick Here2016q4	146.793	19.333,267

Number and percentages of matched edges …		
Quality of matching	Relative to the total number of edges in network	Relative to the sum of edge lengths in the network
IDENTICAL	Count: 134.514 (96,48%)	17878,134 km (94,46%)
GIMME_POSITIVE	Count: 4656 (3,34%)	1005,800 km (5,31%)
GIMME_NEGATIVE	Count: 253 (0,18%)	43,679 km (0,23%)

	Functional Road Class				
FRC	FRC 0	FRC 1	FRC 2	FRC 3	FRC 4
“Matched rate” (in Percent)	98,68%	98,45%	98,23%	98,63 %	86,25 %

$$q_{matched} = \frac{4.656}{(4.656 + 253)} \cdot 100\% = \mathbf{94,85\%}. \quad (1)$$

$$q_{non-matched} = 100\% - q_{matched} = 5{,}15\%. \quad (2)$$

$$q_{\text{success}} = \frac{n_{\text{tp}}}{n_{\text{p}}} \cdot 100\% \qquad q_{\text{error\_detection}} = \frac{n_{\text{tn}}}{n_{\text{n}}} \cdot 100\%. \quad (3)$$

$$\begin{aligned} q_{\text{hit}} &= q_{\text{matched}} \cdot q_{\text{success}} + q_{\text{non-matched}} \cdot q_{\text{error\_detection}} \\ &= 94.85\% \cdot 99.7\% + 5.15\% \cdot 69.0\% \\ &= 98.24\%. \end{aligned} \quad (4)$$

$$q_{\text{effective\_hit}} = 96.48\% \cdot 100\% + 3.52 \cdot 98.12\% = 99.93\%. \quad (5)$$

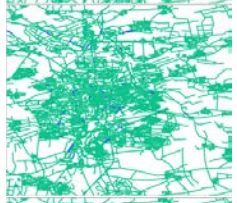
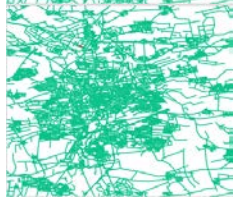
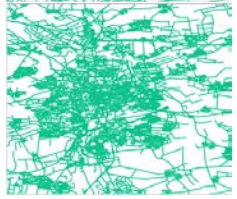
Experimental results

Relocation of link related data between two map

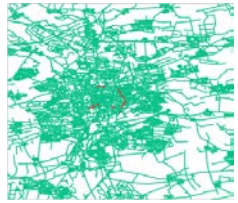
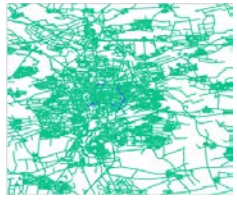
- The tool for the automatic relocation of link related data in an updated map was **evaluated** with **two** test data sets
  - **First data set:** included the locations of a total of **19 Bluetooth** detectors, which are part of RSUs in Brunswick, Germany which are operated by DLR
  - **Second data set:** contained the locations of a total of **236 induction** loop detectors located in the city of Brunswick, Germany and operated by the German company Bellis GmbH

Table 4. Result of the relocation of the test data from old to new map

Number / percentage of matched location test data		
Quality of matching	*Bluetooth detectors*	*Induction loop detectors*
IDENTICAL	Count: 19 (100%)	Count: 171 (72.46%)
GIMME_POSITIVE	Count: 0 (0%)	Count: 64 (27.12%)
GIMME_NEGATIVE	Count: 0 (0%)	Count: 1 (0.42%)

Relocation of induction loop detector data		
Matching quality	Location of loop detectors in “old” map	Location of loop detectors in “new” map
IDENTICAL (171)		
GIME_POSITIVE (64)		
GIMME_NEGATIVE (1)		

236 induction loop det.

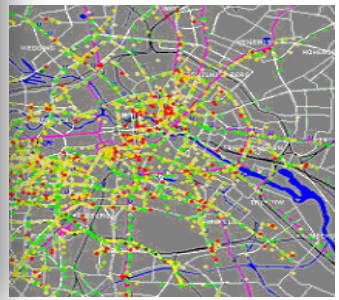
Relocation of Bluetooth detectors		
Matching quality	Location of Bluetooth detectors in “old” map	Location of Bluetooth detectors in “new” map
IDENTICAL (19)		

19 Bluetooth det.

Conclusion

- a prototypic software called “DataRelocator@Map2Map“ is presented.
- This tool is realized with a GUI and enables the automatic relocation of dynamic and static location data in an updated road map
- The technical workflow was formulated in six steps including the inter map matching using the geometry inter map matching extension (GIMME) algorithm
- In addition, the system and the database architecture as well as the GUI have been described
- Digital maps of the manufacturer Here (an “old" map of the release year 2015 in quarter 4 and a “new“ map of release year 2016 in quarter 4) together with test data describing the locations of **Bluetooth** and **induction loop** detectors in the city of Brunswick, Germany have been chosen to demonstrate and evaluate the new tool
- The experiments yielded a hit rate for inter map matching of 98.24%
- The effective hit rate was 99.93% because many edges in the “old" and the “new" map were identical
- by the evaluation with a total of **253 detector** locations all except one location have correctly been relocated in the new map

Thank you for your attention



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