INTEGRATION OF GPS AND CCD CAMERA INTO A MOBILE SYSTEM FOR ROAD INFORMATION SYSTEM

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Abstract

Vehicle Routing Problems reflect the real problems in logistics and transport. The issue to solve it to mark out as best as possible routes for vehicles, which have to serve a group of customers. Marking out suitable routes makes it possible to decrease the total distances covered by the vehicles as well as the time and costs connected with the delivery. Unfortunately, what is proved, obtaining the exact solution of the Vehicle Routing Problem in case of a larger number of customers becomes impossible for the sake of the time required for the computations. This is an occurrence characteristic of the class of NP-hard problems, to which the considered problem belongs. Moreover the problem is so complex that it we can distinguish in it two component NP-hard problems: the Traveling Salesman Problem and the Bin Packing Problem.

The research into algorithmics in this field made possible to find a compromise-obtaining in a reasonable time an approximate solution, which is good enough to sustain the effect of decreasing the costs, time an distance. To this end various optimization algorithms are used. Their working consists in calculating an initial solution with the help of so-called constructional algorithm and then “improving” the initial solution until the stop condition is obtained. The stop condition may mean obtaining a suitable quality of the solution or exceeding the acceptable reasonable time of computations.

In theoretical consideration, for formulizing and testing algorithms, the Vehicle Routing Problems are investigated in the form of points on a plane. For practical application of obtained algorithms the input problem must be formulized accordingly to real situation. An exact description of the real situation is possible if we combine a Geographic Information System with the algorithms solving the Vehicle Routing Problems. Such GIS equipped with appropriate algorithms becomes a useful tool for logistics and transport.

Road management in Croatia is a large domain with many users and applications. Georeferenced data are very important in the road management, representing a basis in GIS for using it as a powerful tool. Data are accessible directly in state coordinate system and therefore easily connected into existing geospatial databases. A road database consists of an inventory of features, topology and attributes. Most of this information can be collected using different surveying techniques. Surveying system represented in this paper is advanced technique for dynamic surveying of road network and its surrounding objects. Several devices are mounted on a mobile terrestrial vehicle that performs an automated survey of specific road features such as centerline, road condition, road signs and other road inventory. Mounted devices are real time integrated, and include Global Positioning System (GPS) receiver, Charge-Coupled Device (CCD) camera and odometer. Applied techniques and procedures ensure gathering georeferenced data in rather short period of time. Capturing road data with such system offers quick and reliable method for updating road database. This kind of surveying is more challenging than the conventional surveying methods but the performance is enlarged and manpower requirements are decreased.

Introduction

Road management companies are using GIS tools to support a range of functions, including traffic monitoring and management, infrastructure planning and maintenance, safety and accident analyses, and vehicle routing.
Accurate road database is foundation for GIS and it is used in many countries for road maintenance and management. A road database consists of an inventory of features, topology and attributes. Most of this information can be collected using different surveying techniques. Surveying system represented in this paper is an advanced technique for dynamic surveying of road network and all its surrounding objects. A mobile system involves a vehicle that is equipped with:

- A positioning system – Global Positioning System (GPS) device for collecting coordinates in state coordinate system and an odometer (wheel sensor) to measure the covered distance.
- An imaging acquisition module – Charge-Coupled Device (CCD) camera to record the road and its surroundings. The imaging module is synchronized with GPS to get positioning and attitude of each image.
- A data processing module that combines positioning data and images in order to get position of the desired object.

Current organization of road data based upon length measurements are not giving the real and absolute position of the road and their surrounding objects. That is the reason why georeferenced measurements of road geometry and road objects present a new concept in generation of road databases, and why georeferenced data are required.

**System design and idea**

With the constant improvement of the GPS and its accuracy, combined with improvements in video imaging technologies, GPS based video logging systems offer a fast and low cost approach for collecting road data. The collected video images can be georeferenced into a state coordinate system using GPS device and positioning information. Furthermore, the digitally georeferenced video data enables quick retrieval and effective management of collected data, with possibility that collected geometric and attribute information can be directly used to insert new and update existing data in the road database with improved geometry accuracy.

A mobile system consists of three components: data acquisition, information extraction and information management.

A vehicle that combines a precise positioning system with a horizontally oriented CCD camera is used in order to collect data. The system consists of GPS receiver and a progressive scan CCD camera connected to processing unit. The GPS antenna is mounted on the top of a van. The position data and the digital image records are synchronized, allowing geo-coding of the captured imagery. The positioning system determines the trajectory of the vehicle that approximates the center of the road. Mounted devices on a mobile vehicle will perform an automated survey of specific road features such as centerline, pavement condition, road signs and other road inventory.
Information extraction from collected data is processed in the office. The final products are updated data with higher precision in the road database that can be used with GIS tools for information management.

**Video**

Video system implemented in a vehicle consists of the progressive CCD camera that is linked to video capture card on a computer to control camera operation and image capture. Images are grabbed with 25 frames per second directly to the hard disc, while the same video is saved on miniDV media for backup. Due to the low resolution of video images and limited hard disk space, quantitative measurements from these images are still limited, but are enough for the purpose they are intended. From saved video frames it is possible to acquire both semantic and metric data. Semantic data are pavement condition and surrounding object of the road, while metric data are road width and traffic signs height.

To assure quality of metric data video camera must be properly calibrated. Camera calibration has to be done every time before starting the measurement and at the end of measurements. This assures that in case of accident camera movement, correction can be applied later. Calibration has to be carried out in few steps that include measurement of known vertical and horizontal length that will be later used as comparator length.

The weather condition has big influence on the quality of the video image. The best conditions are in cloudy days but without rain. Video images taken at these conditions are not so colorful but there is no other harmful effect. During rainy days measurements are not possible, road is full of water and collected data are not complete, because estimation of pavement surface condition is not possible. Bright light and direct sun into camera causes that some objects are not fully or at all visible.

**GPS**

The main tool for data and video georeferencing is GPS system. During the survey it is impossible to ensure GPS signal without interruption due to the configuration of satellites, terrain and obstacles. Therefore it is required to have some alternative source of data to serve as a backup when the GPS signal is lost. The best solution would be combination of Global Positioning system with Inertial Navigation System (INS) that
continuously controls current position and changes of the position. Integration of GPS and INS system provides best results, but it is quite expensive technology. Decision was made to use low cost solution that still assures needed accuracy.

We used GPS with activated commercial differential correction that assures sub-meter accuracy in good condition, in combination with odometer that constantly measures the covered distance.

Software

Complete mobile vehicle system was custom and handmade. Therefore, there was no available proper software to fit our demand. That is why we have developed our own software:

- Software for collecting data that is used in a mobile vehicle.
- Software that is used in the office for post-processing collected data.

The main tasks of the software for collecting data are to control and guide through the process of collecting data, to ensure synchronization of the GPS measurements with odometer measurements, synchronization of GPS measurements with video images, and to warn if malfunction appear.

Software consists of three parts.

- Window with the picture from camera so that all the time is controllable if the camera is properly placed and that collected image will include the whole road with surroundings objects.
- Window with interactive map, with existing road network and other features needed for proper and easier acquisition. Map can be used for navigation because the GPS constantly provides a coordinate of the vehicle that is represented on the map with a point. With every new signal from GPS, new point is charted on the map.
- Window with controls that synchronize GPS, odometer and camera, and additional comments and attribute that will be written in the database with the rest of the collected data.

![Figure 3. Software for collecting data](image)

The main tasks of the software for processing data are to help analyzing video image.

There are two windows for reviewing collected video image. Beneath video images are measurements and attributing commands. All attributes are written into the road database.
Collecting and processing data

During the measurement in the field video capture drive is capturing video from the CCD camera that is written on the hard disk. In the same time in the database is written number of every frame, while the data from GPS and odometer are written into database, as they are measured and ready from the proper device. Both data are captured independently. GPS data are captured in 1-second period while the video time unit lasts 1/25 of a second.

Collected input data for data processing consist of camera calibration data video images, and trajectory. Average speed of surveying vehicle is between 30 and 50 km/h. Speed of the vehicle is adjusted accordingly to road and traffic conditions. In an open and straight road, vehicle speed is increased up to 60 km/h. The data collected this way results with less points in straight roads, and with more GPS points in winding roads.

The first step in data processing is interpolation of intervals between 1 second of the GPS and odometer data in the database, so that every frame is georeferenced – every frame has its coordinate (GPS) and relative length (odometer).

The second step in data processing is from collected trajectory of the vehicle gathered from GPS to improve the existing geometry of the road information system.

The final step is processing semantic data provided from video that includes georeferenced and condition traffic signs, other surrounding object and condition of the road.

Improvements

Improvement of the systems is possible, like adding an additional CCD camera on the backside of the vehicle that will capture traffic signs in opposite direction. That improvement can be easily integrated in the existing system, and will save time because there would be no need for passing roads in both direction. Additional accuracy improvements are also possible.
Conclusion

An existing mobile vehicle system that is described ensures expected results and accuracy. It will be used for road data acquisition of public roads across the Croatia and for the improvement of road information system.

Bibliography

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