Video Segmentation and Video Segment Structure for Virtual Navigation

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Abstract: In recent years, the use of video in GIS is considered to be an important subject and many related studies result in VideoGIS. The virtual navigation is an important function that can be applied to various VideoGIS applications.

For virtual navigation by video, the following problems must be solved.

1) Because the video route may be not exactly coincided with route that user wants to navigate, parts of several video clips may be required for single navigation. Virtual navigation should allow the user to move from one video to another at the proper position.

We suggest the video segmentation method based on geographic data combined with video.

2) From a point to a destination, the change frequency of video must be minimized. The frequent change of video make user to mislead navigation route and cause the wasteful use of computing resource.

We suggest methods that structure video segments and calculate weight value of each node and link.

Keywords: virtual navigation, video segmentation, video segment structure, VideoGIS

1. Introduction

In recent years, the use of video in GIS is considered to be an important subject and many related studies result in video-based GIS, VideoGIS. The VideoGIS aims at constructing geo-referenced video material and serving various human-oriented GIS application.

The virtual navigation is an important function that can be applied to various VideoGIS applications, car navigation, personal navigation, tourist guidance, etc. Users can be provided with the realistic and human-perceptible video information about road signs, buildings, and other details of interest as well as the roads that user wants to navigate.

In order to provide video virtual navigation service, the following problems must be solved.

1) Video Segmentation: Virtual navigation may not look natural if the viewing image changes suddenly in direction at the crossing. It is necessary to have 12 runs per crossing – right, left turn and straight from four directions. Always we consider that the set of videos may be restricted.

2) Structuring video segment: During a virtual navigation, change frequency of video must be minimized, because the change of video may cause the wasteful use of system resource and make user to mislead video route. Besides, navigation route should approximate the shortest path on road network.

In this paper, video segmentation and construction of video segment based on geographic contents for virtual navigation is studied.

2. Data Acquisition

The VideoGIS deals with two kinds of information: on the one hand, it manages a collection of videos that are spatially located, and on the other, it manages geographic data. This geographic data includes from location/attitude data of video camera as raw data to more processed vector features whose types can be points, lines and polygons.

The video data is gathered by a mobile mapping system called 4S-Van that has been developed in our previous research [4]. Mobile mapping system is a vehicle that various sensors, GPS/IMU, CCD camera, and video system, are integrated to obtain 3-dimensional coordinates of geographic object.

Fig. 1. 4S Van: a vehicle that collects video data and GPS/IMU data.

The location and attitude information of video camera can be acquired by GPS/IMU in 4S-Van. The geographic objects on the video frame can be extracted by object recognition and tracking methods and recorded in corresponding video frame.

3. Video Segmentation

Because the video route may be not exactly coincided with route that user wants to navigate, parts of several video clips may be required for single trip. Virtual

navigation should allow the user to move from one video to another. So, points changed from one video to another should be searched for video segmentation.

If we want to attach to segments is related to the geographic features present in the video, a segment may be defined as a set of contiguous frames containing the same set of features [1]. But, for virtual navigation, a segment is defined as a set of frames from video changing point to the next video changing point in a video.

The handmade segmentation of video is too expensive and time-consuming. For the automatic segmentation of videos, geographic data combined with video are used. The geographic data combined with video include the location/attitude of camera at each video frame, and object information in each video frame – such as building, road sign, etc.

The following methods may be applied to find video changing points automatically.

1) Find the frame numbers of video images acquired at a close distance and similar forward direction. These video images are in each different video. If in the same video, the frame numbers of video images must not be continuous.

2) Find the frame numbers of video images where appear the same geographic objects in different frame images. These video images are in each different video. If in the same video, the frame numbers of video images must not be continuous.

Fig. 2. shows an example of two neighboring video routes at a crossing. To operate left turn represented a dotted arrow line, virtual navigation should be changed from video **A** to video **B**. As result of the method 1), changing point **a** for video **A** and changing point **b** for video **B** were acquired.
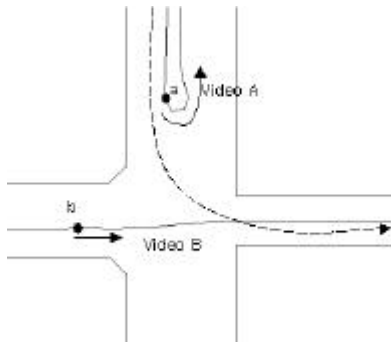

Fig. 2. Example of video routes at a crossing

As shown in Fig.3. video **A** was segmented to **C, D** and **B** was segmented to **E, F**. In order to operate left turn, virtual navigator play video segment **C** and **F** sequentially
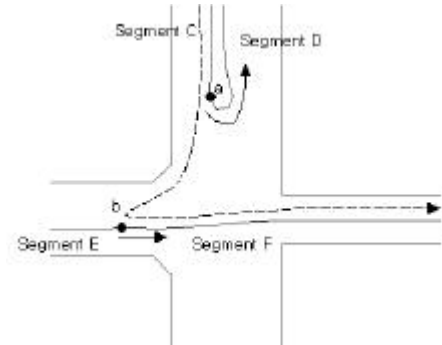

Fig. 3. Result of virtual navigation route at a crossing

Fig. 4. shows two video images on each changing point, as result of the above example. The left image is the last frame image in segment **C**, and right is the first frame image in segment **F**. Two images are taken the same crossing, but navigators may not understand that
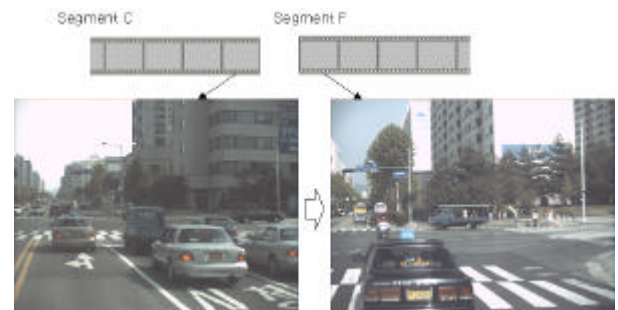

Fig. 4. Video images at each video changing point

Against this problem, one option promoting user's understanding is that the additional information is represented during passing through a changing point.

Fig. 5. shows the use of symbol indicated left turn. In a symbol represented the crossing, dotted arrow line symbol represent virtual navigation route, and short solid arrow line represent the current location and direction of navigator.

This symbols can be drawn on video player whenever pass through a crossing. The representation of additional information, such as graphic symbols or audio, provides more understandable information to navigator.

Fig. 5. Representation of additional information as graphic symbols.

4. Video Segment Structure

The set of video segments are structured by the well-known network data structure. Video changing points at a road crossing is regarded as a node on network

structure, and a vehicle route between two nodes is treated as a directed link. And, the video changing point is regarded as turning point with penalty value. Fig. 6. shows the abstract network model for video segment data.
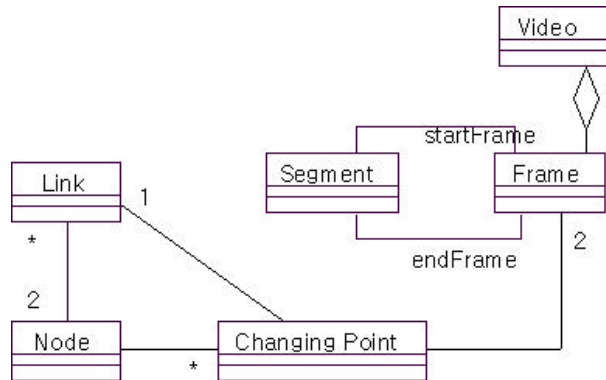

Fig. 6. Abstract model for video segment data

Video changing, geographic data and the use of computing resource influence the value of turning penalty.

Geographic data:
   -How close is distance between changing points?
   -How similar are forward directions at each changing points?
   -How many the same objects are in each different video image?
   -What area of region token up by the same objects in each different video image?
Computing resource:
   - What is video file size?
   - Was loaded video file already in memory?

The link, a part of vehicle route between changing points, has the weight value. This weight value is calculated considering geographic distance and link passing time.

Fig. 7. Example of video routes

Several video routes represented red solid lines in Fig.7. can be structured like left image of Fig.8.
In order to search the shortest path, the widely used link-labeling algorithm was applied. When nodes that

have turning penalty appear repeatedly like this case, the link-labeling algorithm is a good solution to finding cheapest path. When the link-labeling algorithm is applied, the link is regarded as a node, and changing point is regard as a link. A list of video segments as result of cheapest path search is returned.

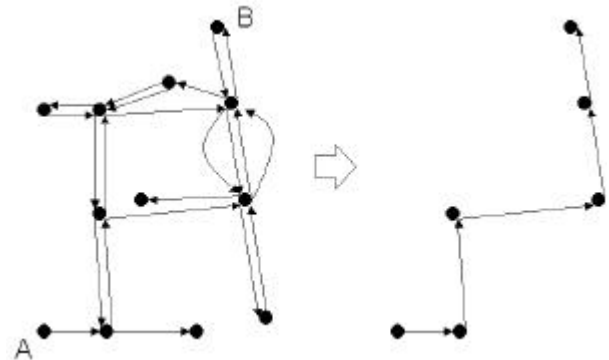The right image of Fig.8. shows virtual navigation route as cheapest path passing from node **A** to node **B**.

Fig. 8. Result of cheapest path search

5. Conclusions

In this paper, video segmentation and video segment structure based on geographic data for virtual navigation are suggested.

For video segmentation, we suggest the segmentation method based on geographic data combined with video, And for user's understanding, we suggest the representation of additional information, such as graphic symbol.

We suggest methods that structure video segments along with network data structure and calculate weight value of each node and link considering video chaning, geographic data and computing resource.

Virtual navigation service applied the suggested methods can convey route information to navigators effectively and understandably.

References

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