On Road Navigation System Using Spatial and Motion Image Processing for Automatic Navigation System

Niladri Sekhar Dey, Ramakanta Mohanty, and K. L. Chugh

***Abstract*—Triggered by the spread of digital aerial image processing and necessary of automatic road navigation systems, this has become a topic of consideration and research. Within our research improving the navigational direction systems based on aerial image acquisition, spatial image acquisition, registration of aerial image onto spatial plane and mosaicing of aerial image frame and spatial image is considered. These techniques then can be applied in order to improve the quality of image registration, image restoration and image mosaicing techniques. In our investigation such a method of registration and restoration is realized based on derivative non linear processing of image sequences. This type of algorithm is especially suitable when huge dataset of aerial images and non stable dataset of spatial images are needed to be mosaic. Additionally on road navigational systems require obstacle removal in high speed, this also will be demonstrated in final part of this paper.**

***Index Terms*—Aerial Image, image mosaicing, image registration, intelligent navigation system, obstacle region detection, spatial image.**

I. Introduction

Directed road for automatic maps are most important components for any on road navigation system for machine – human leaded navigation[1][2]. Although many navigational systems are available with Aerial, 3D and 2D image maps based. Still various limitations limit the performance of Intelligent Road Navigations Systems. As one of the applications, a road image can be used for localization. Localization is performed by association and matching between aerial image and spatial image. However, aerial images are obtained from web services, which are naturally low in resolutions and do not contain any information of obstacles on road and the spatial images are obtained from the ground camera, which do not contain the information about occlusion and effected by the acceleration of the ground camera device. Also, since the positions of the obstacles on the road are changing their positions, spatial images need to be updated frequently. Therefore, it is required to improve the resolution of aerial image, mapping the aerial image into ground camera position based on longitude and latitude, inclusion of occlusion and finally stabilization of the road image. Conclusion of all information into aerial or spatial image is costly as aerial image capturing is costly. Hence the objective of this research focuses more on retrieving best maps. When the aerial images are made available from some web services and ground image can be made available using imaging devices, hence here in this research we propose an algorithm to mosaic aerial and spatial images to determine best navigation maps. This algorithm involves the extraction of aerial [Fig 1] and spatial motion picture [Fig 2] and then comparison of two images [Fig 3].

Fig. 1. Sample aerial image.

Fig. 2. Sample spatial image.

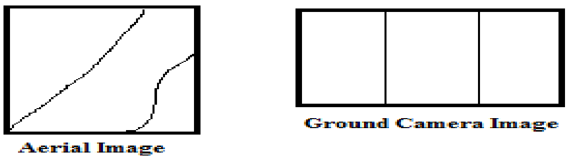

Fig. 3. Comparison of Fig1 and Fig2.

The rest of the paper is organized as: We introduced the related work in Section II, the proposed methodology in Section III, setup and discussions in Section IV and conclusion in Section V.

II. Related Work

The majority of navigation system algorithms follow an approach to manage the road navigation [3] using only below mentioned strategies [4][5][6]. Hence the subsequent problems occur. For our convenience those are classified in three different types in this study to justify the improvised method of navigation.

A. *Type One Navigation System:*

Using only aerial imaging techniques the navigations maps are constructed, thus the images are low in resolutions; hence the systems demands high performance image processing operations like Aerial Domain Resolution operations using image registration [7][8][9][10] and so. More over the

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occlusion of obstacles are ignored or the aerial maps need frequent updates for better and reliable performance.

B. Type 2 Navigation System:

Using only 2D imaging techniques the navigation maps are constructed, thus the depths of the static obstacles are hidden. Hence the navigation system compromises on appropriate navigation speed and navigation directions.

C. Type 3 Navigation System:

Using only 3D imaging techniques the random maps are to be generated; hence the navigation system works slower, more over the updating road maps become difficult as the aerial images and not incorporated while generating navigation directions.

Considering the types of human – machine interactive navigation system, in this research a new type of navigation prototype is proposed as On Road Navigation System using Aerial & Spatial Image processing which is less costly and removes the cumulative errors taking aerial image as reference.

Recently after the release of many web services, the aerial images are relatively easily available. Those aerial images have high accuracy. Therefore by using those aerial images as reference image, the image mosiacing [11][12][13] can be performed perfectly. Although, the spatial image has effect of acceleration and time constant, hence it is important to normalize the image sequence. Hence we have included those processes in our algorithm.

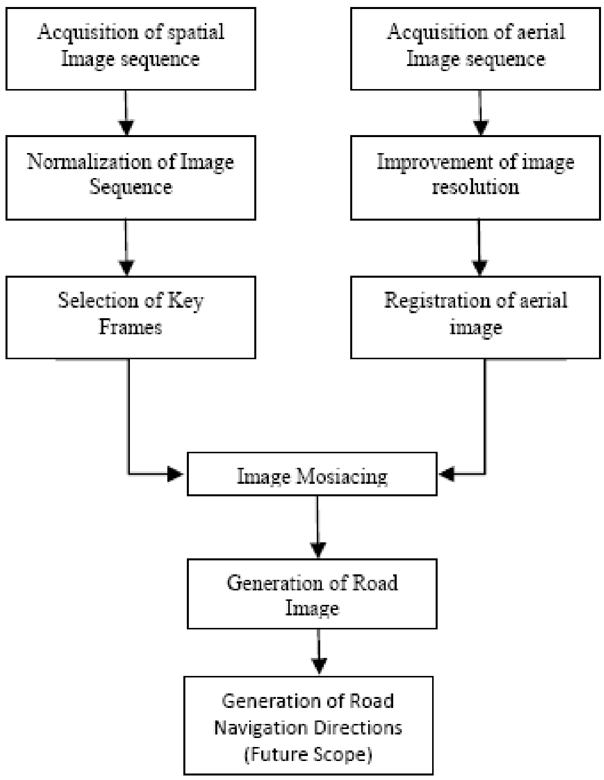

Fig. 4. Processing flow.

III. PROPOSED METHODOLOGY

A. Strategy

This algorithm involves the extraction of aerial [Fig 1] and ground spatial motion image [Fig 2] and then Mosaicing of two images [Fig 3].

The algorithm is divided into five parts as

1) Acquisition of spatial image sequence.
2) Normalization of Image Sequence or Removal of acceleration effects of spatial image.
3) Finding the key frame from spatial image sequence.
4) Finding the key frame from Aerial Image.
5) Mosiacing of spatial and aerial key frame.

B. Acquisition Spatial Image Sequence

The process flow of the proposed method is shown in Fig. 4. An Input is a spatial images sequence from an in vehicle camera. The spatial image sequence is accepted as G_M, which is having acceleration effects. Hence removing the acceleration effects is the next task.

C. Normalization of Image Sequence

To remove the acceleration effects from the image sequences, we try to normalize the image sequences by time and accelerations components of the in vehicle camera.

We denote the spatial image set as G_M.

Now to remove the acceleration effects from the image sequence and to find the image frame we perform the following operation

$$\triangle G_M = \frac{\delta}{\delta x}[G_M] \tag{1}$$

Now Δ GM is free from the acceleration of the in vehicle camera, but to find the image at a specified time t, we again perform the following operation.

$$\triangle G_{M_T} = \frac{\delta}{\delta x}[\triangle G_M] \tag{2}$$

where $t \longrightarrow 0$

D. Finding the Key Frame from Spatial Image Sequence

To find the key frame, in which the obstacles are available occupying a notable area, we apply region detection algorithm to find the area of obstacles occupied in each and every frame and as a result we find a graph [Fig 7] denoting the area occupied by obstacles in each frame.

Here to find the key frames we consider a value ϴ, which denotes the cut-off for selection of key frame. Hence we get the following formulations as [Table I]

$$\triangle G_{M_T} \doteqdot \mathrm{R}_{M_{T\theta}} \tag{3}$$

where as,

$\theta > 25{,}000$, Then Accepted As Key Frame.

Else, Rejected

E. Finding the Key Frame from Aerial Image

We denote the aerial image set as I_A. Now to improve the resolution we impose a function called Rez on the aerial image set.

$$\Delta I'_{A} = \mathrm{Re}\, z[I_A] \tag{4}$$

Now to register aerial key frame for spatial key frame, we impose a function called CoD based on the coordinates received from ground camera as (x,y) coordinate.

And receives,

$$\Delta I'_{A(X,Y)} = CoD[\Delta I'_{A}] \tag{5}$$

Fig. 5. Spatial Image key frames Sequence (Data Set 1).

Fig. 6. Aerial Image after image registration (Data Set 2).

TABLE I: REGION OF OBSTACLES IN EACH FRAME

Frame Set	Object Region	Image Region
Frame 1	38908	288000
Frame 2	28193	288000
Frame 3	15438	288000
Frame 4	4902	288000
Frame 5	4048	288000
Frame 6	1533	288000
Frame 7	0	288000
Frame 8	0	288000
Frame 9	0	288000
Frame 10	0	288000

F. Mosaicing of Spatial and Aerial Key Frame

From the Eq 3 and 5, we need to mosaic final frames. Hence we consider $R_{Mt\Theta}$ and $\Delta\ I'_{A(x,y)}$ as matrix, where $\Delta\ G_{Mt}$ is denoted as

$$\Delta G_{M_T} = \begin{pmatrix} a_{11} & a_{12} & \phi \\ a_{21} & \phi & a_{23} \\ a_{31} & \phi & a_{33} \end{pmatrix}$$

Where Ø denotes No Object is image space. Hence for the mosaicing operation we perform simple multiplication of matrices as

$$\Delta DI_{(x,y,t)} = \mathrm{R}_{M_{T_\theta}} X \Delta I'_{A(X,Y)}$$

Which results in $\Delta\ D_{I(x,y,t)}$, where the result of multiplication nullifies all the elements of $\Delta I'_{A(x,y)}$ matrix overlapping with Ø in $\Delta\ G_{Mt}$ matrix. Hence we got our final key frame for generating road navigation.

IV. SETUP

We performed the above mentioned approach using spatial image and aerial image dataset [Fig 5 and 6]. Now we demonstrate details of setups and results. In this experiment, we used two datasets which consists of a spatial image sequence and an aerial image dataset. This spatial dataset has been collected from an in-vehicle camera, where the vehicles were in different motions. The in vehicle camera was with a resolution of 640 x 450 pixels and the frame rate was 30 fps. The used parameters were as $w = 10$, $h = 20$ and $l = 5$.

V. CONCLUSION

Within this paper, the improvement of the resolution of aerial image key frame, effective selection of spatial image frames and followed by mosaicing of both the key frames were done to improve the on road navigation of human – machine interactive navigation. This approach even can be applied for machine learning for an unguided vehicle for on road navigation. More over the same approach can be combined with an audio translation system to have an automatic navigation system for blinds.

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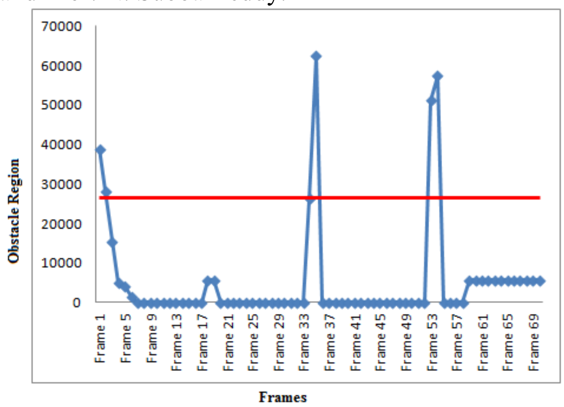

Fig. 7. Frame wise obstacle area.

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