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DESIGN AND IMPLEMENTATION OF ROBUST AND DYNAMIC TRAFFIC FRAMEWORK WITH KNOWLEDGE BASED VISION COMPUTING SYSTEM

Pardeep Mittal[1] and Yashpal Singh[2]
[1]JNU Jodhpur and Lovely Faculty of Technology and Science, LPU Jalandhar, India
[2]Somany Institute of Technology and Management, Rewari, India
E-Mail: pkm.gagi@gmail.com

ABSTRACT

This paper describes the design and implementation of dynamic and robust traffic management system based on fuzzy logic approach. Knowledge based system have been extensively adopted as approach for real time decision making system. As the conventional dynamic controllers were used sensors which are having certain limitations, so these limitations can be overcome by vision sensors i.e. camera. Also image and vision computing plays a important role in monitoring and measuring the traffic density on road. Problems were identified with the current traffic control system at the intersection on road and this necessitated the design and implementation of a new system to solve the congestion problems.The performance of the proposed method is evaluated with LabVIEW and MATLAB test bed. The results of extensive simulations using the proposed approach indicate that the system improves the average moving time and decrease the average waiting time than the controllers with conventional sensors.

Keyword: traffic density measurement, fuzzy expert system, traffic lights, vision computing, intelligent controller.

1. INTRODUCTION

Road traffic jam is a major problem in developed countries. For a person, congestion means time wastage or loss of time, missing of opportunities, and getting frustration. It also adversely impacts the industries due to productivity loss of the employees, loss of trade opportunities, delayed delivery. Common methods of conventional traffic light controls are time of day control; fix time control, area dynamic control. In each case the overriding goal is the same, to maximize safety, speed, and energy efficiency or minimize waiting time, number of vehicle stops. This is not a simple problem in a dynamically changing traffic environment in which each traffic light system must take account of a wide range of variables, such as an intersection type of being single-lane or multiple-lane, traffic volume, time of day, the effects on other roads, and the involvement of pedestrian traffic.

Artificial intelligence methods such as ANN[1], Fuzzy Expert system[2] and intelligent decision making system for urban traffic IDUTC[3] are reported in literature. However no such a system has developed which meets the adaptive characteristics like the minimum time to take the decision for ON/OFF timings of RGY lights. Many studies and statistics were generated in developing countries that proved that most of the road accidents are because of the very narrow roads and because of the destructive increase in the transportation means [4].

Traffic light is one of the most significant factors in the management of the traffic. Traffic light signs are that signs erected at the sides of the roads to provide information to road users. It has been proven that traffic signal timing and coordination of existing signals reduce significantly in traffic delay, energy, travel time and this consequently results in increased safety for the public. Due to poor strength of traffic police, it is impossible to control traffic manually in all area of city or town. For this reason, researchers got interested in developing efficient real-time traffic signal control. This idea of controlling the traffic light efficiently in real time has attracted many researchers to work in this field with the goal of creating automatic tool that can estimate the traffic congestion and based on this variable, the traffic sign time interval is forecasted.

2. PROPOSED TRAFFIC MANAGEMENT FRAMEWORK

Figure-1Shows closed loop control system, in which comparator or error detector gives the information of average pixel to pixel matching of reference mosaicked image and Current mosaicked image. Here multiple vision sensors have been used instead of conventional sensors like IR, ultraviolet sensor, inductive loop sensors that were used in conventional controllers. In addition Fuzzy controller have been used for better decision making to vary the.

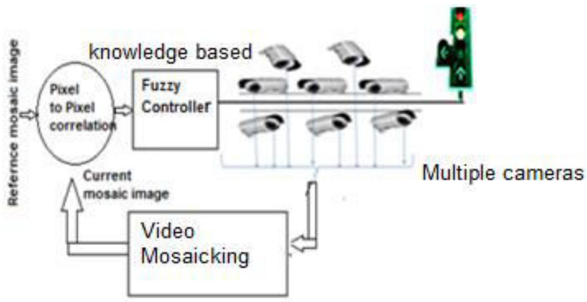

Figure-1. Schematic diagram of proposed method.

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timings of green/red lights as per density measured on road on the basis of membership function and rule based fuzzy sets manipulated by output of error detector. In feedback loop, vision sensors has been used for capture the images of traffic

The use of multiple vision sensors are only so that it can measure the exact gap between vehicles to accurate measurement of traffic density. After capturing the images, the image passes though number of steps like saves the images, grey conversion, transformation, wrapping, compositing and finally mosaicked image formed.

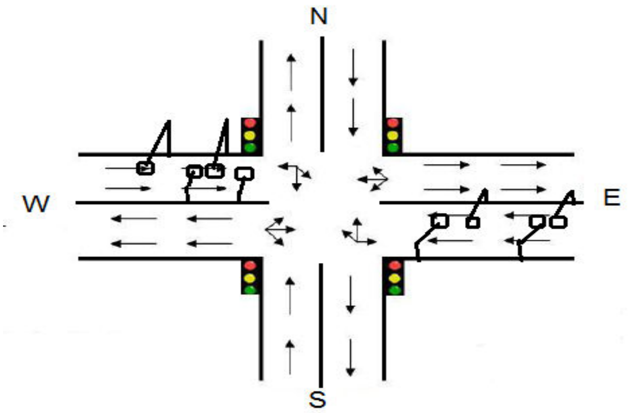

Figure-2. Schematic diagram of '+' Junction type intersection.

Figure-2 Shows the schematic diagram of proposed framework on '+' shape road. 4 web cameras of 12.0 mega pixels have been installed on each side of road. It has been assumed that in W-E and E-W direction there are two lanes in each side as heavy traffic passes in these directions as compared to N-S and S-N which is having single lane due to low traffic on these directions. The proposed algorithm works in such a way when normal traffic is detected, the timings remains same as set earlier. But when algorithm detects traffic more than normal (normal traffic measurement range may be obtained from past data), timings of red/green lights varies accordingly. As macroscopic traffic flow model deals with average density, average velocity and average speed of traffic but in this proposed framework only traffic average density has been considered as parameter of macroscopic traffic flow model.

3. KNOWLEDGE BASED FUZZY EXPERT SYSTEM

Fuzzy Controller receivers the crisp data from error detector which may be basically similarities and dissimilarities between current mosaicked image and reference mosaicked image. For finding the similarities between two images corner detection technique [5] has been used

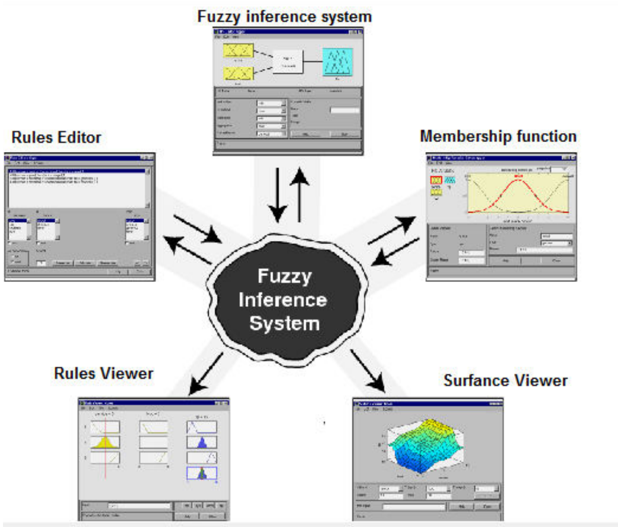

Figure-3. Architecture of Knowledge based FES.

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The main purpose of fuzzy inference is to simulate the decision-making which is based on the fuzzy logic and approximate inference. As a rule, a fuzzy "IF (condition), THEN (conclusion)" will be taken to show the relationship between the input and output of a system. Considering that there is one feature that can affect the judgment of the edge and the judgment has its fuzziness, it will take a fuzzy consequence to do a fuzzy measure of the edge which contains one fuzzy input and one fuzzy output. . Image Mosaic based on Cornerpoints after extracting the corner features of surveillance images, we will locate the boundaries range for splicing. This is done by pre-calibration of the camera position. The two cameras with the same internal parameters are set in the appropriate position. So the overlapping portion of two images will be known. After getting the overlapping portion of two images, we will count the maximum similarity [5, 6] between two images pixel values in the overlapping portion of two images. We should find every point in reference mosaicked image has a corresponding point in current mosaicked image only, and the two points are regarded as the same position.

Let $X_1(x_1, y_1)$ and $X_2(x_2, y_2)$ be two random characteristic point of reference mosaic image and current mosaick image then correlation coefficient is defined as:

$$Corr(X_1, X_2) = \frac{Conv(X_1, X_2)}{SD(X_1) \times SD(X_2)} \quad (1)$$

In the equation (1) SD and Conv. are the standard deviation and correlation functions respectively as follows:

$$SD(X) = \sqrt{\frac{\sum_{i=-n}^{n}\sum_{j=-n}^{n}[(x+1, y+1) - M(X)]^2}{W}} \quad (2)$$

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$$Conv(X_1, X_2) = \frac{\sum_{i=-n}^{n}\sum_{j=-n}^{n}[I_1(x_1+i, y_1+j) - M(X_1)][I_2(x_2+i, y_2+j) - M(X_2)]}{W} \quad (3)$$

In equation (3), $M(X)$ is value of grey pixel of relevant part in reference mosaic image I_1 and current mosaic image I_2

$$M(X) = \frac{\sum_{i=-n}^{n}\sum_{j=-n}^{n} I(x+i, y+j)}{W} \quad (4)$$

So, in the two images for matching, we select one point (x, y) as the initial point in image 1, and roughly locate the corresponding image point (x, y) in another image 2 depending on translation component in the direction of mosaic. Next, we set certain steps i, j, and according to the principle of maximum cross-correlation coefficient do iterative search until the best splice point is acquired. Finally, the images can be stitched by the best matched corner feature point pairs based on coordinate transformation.

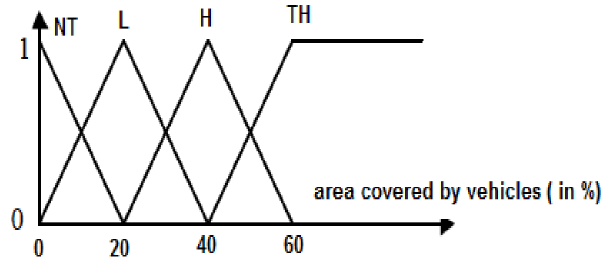
A. Input and output member functions

For the traffic light controller, four possibilities or member functions for each fuzzy input and output variables are required which are shown in Table-1.

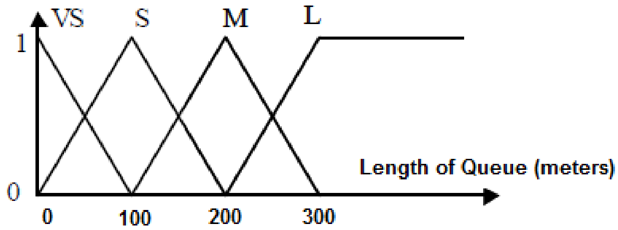
Table-1. Fuzzy variables for arrival, length of queue and extension in time.

Arrival		Length of queue		Extension	
No Traffic	**NT**	**Very small**	**VS**	**Zero**	**z**
Low	L	small	S	short	S
high	H	medium	M	medium	M
too high	TH	large	L	longer	L

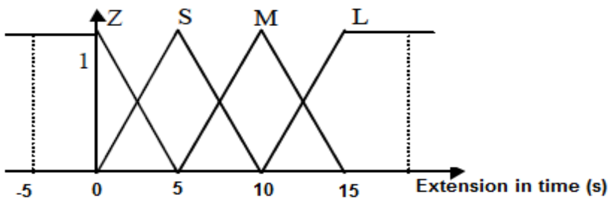
If the junction is too congested, the number of cars in the fuzzy subset "Too High" or "Large" then extension in timings is needed. On the other hand, for a less congested junction the width of the membership functions can be reduced. It can be observed that in fuzzy logic control the transition from one fuzzy subset to another provides a smooth transition from one control action to another, thus, arises the need to overlap these fuzzy subsets. If there is no overlapping in the fuzzy subsets then the control action would resemble bivalent control (step-like action). On the other hand if there is too much overlap in the fuzzy subsets, there would be a lot of fuzziness and it performs the control action. Figure-4. Shows Graphical representation of membership functions of the fuzzy logic controller.



(a) Input Fuzzy Variable: Arrival of Vehicles (covered area)



(b) Input Fuzzy Variable: Length of Queue



(c) Output Fuzzy Variable: Extension in time

Figure-4. Membership functions of fuzzy logic controllers.

On the basis of all possibilities shown above decision making can be done how extension in time is required for different cases. This is shown in Figure-5.

Arrival

Queue	NT	L	H	TH
VS	Z	S	M	L
S	Z	S	M	M
M	Z	Z	S	M
L	Z	Z	Z	S

Figure-5. Fuzzy rules in matrix form.

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4. DESIGN CRITERIA AND CONSTRAINTS

In the development of the dynamic traffic lights control system the following assumptions are made:

a) The junction is an isolated four-way junction with traffic coming from the north, west, south and east directions;

b) When traffic from the north and south moves, traffic from the west and east stops, and vice-versa;

c) No right and left turns are considered;

d) iv)The dynamic logic controller algorithm will observe the density of the north and south traffic as one side and the west and east traffic as another side;

v) East-West lane is assumed as the main approach

5. VISION COMPUTING

Image mosaicking is the process of smoothly piecing together overlapping images of a scene into a larger image. This operation is needed to increase the area of coverage of an image without sacrificing its resolution. Due to the limited size of digital images, it is sometimes not possible to include an area of interest in an image. In such a situation, overlapping images are obtained and the images are combined into a larger image through image mosaicking. An image mosaic is created from a set of overlapping images by registering and re-sampling all images to the coordinate space of one of the images. An image mosaicking system has to take into consideration the relation between the cameras, distances of the cameras to the scene, the scene content, and the characteristics of the cameras. As Shown in Figure-6 image mosaic process consists of three steps: Image Transformation, Image Blending or warping and Image compositing or stitching.

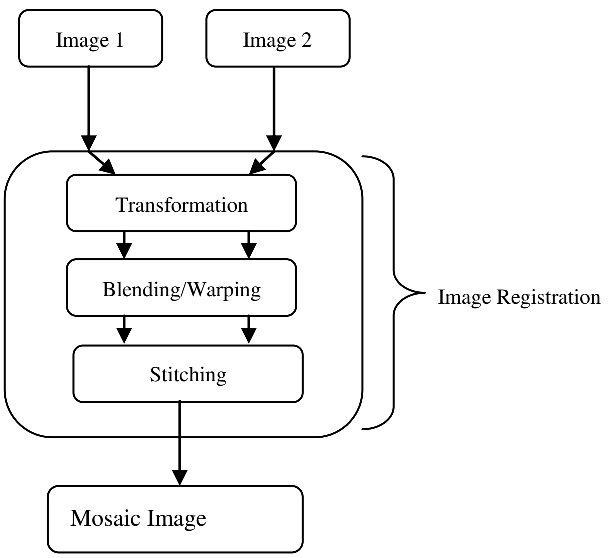

Figure-6. Flow chart for Image Processing.

6. ALGORITHM FOR PROPOSED FRAMEWORK

Algorithm has following steps

1) Acquire the images from individual cameras during Red light and saves them automatically in data base.

2) RGB Images are converted in to gray scale images.

3) Gray scales images are transformed in to different projections to meet the properties of pixel to pixel.

4) Projected images are warped or blended so that pixels of projected images perfectly match throughout the region.

5) Blended images are stitched or composited to make one image called mosaicked image which gives the information of images taken from different angles earlier.

6) Steps 1-5 repeated for reference image just after 2 seconds when red becomes ON.

7) Algorithm waits until reference mosaicked image and current mosaicked image formed.

8) Pixel to Pixel matching of both mosaicked images performed.

9) The average matching of both mosaicked images gives the command to rule based fuzzy controller and timing of Red/Green lights varies according to that.

Steps 1-9 executes during the red light so that timings of green light may be varied. For example if total time is given to red light + green light is 60 seconds and if traffic on N-S road is more than normal then timing of green light will be 50 seconds and timing of red light will be 10 second. The set timings are arbitrary values.

7. EXPERIMENTAL RESULTS

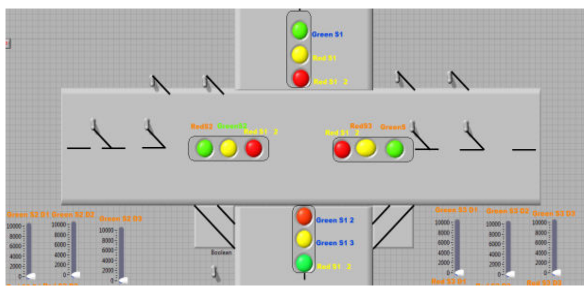

Figure-7. Lab VIEW simulation test bed (GUI).

To check the performance of proposed framework, Lab VIEW simulation test bed has been used

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as shown in Figure-7. In GUI '+' type road has made with vision sensors to check the variations in timing of Red/Green lights whereas Figure-8 shows the logic behind the constructed GUI.

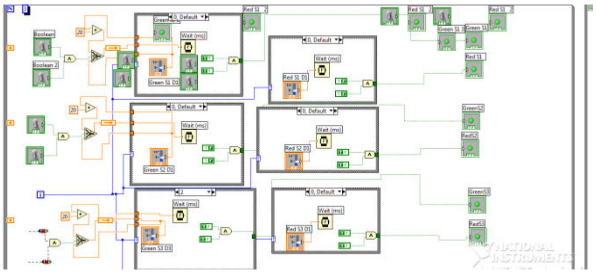

Figure-8. Lab VIEW simulation (block diagram).

Figure-9. Shows the two images captured at different projections. After processing these images, final mosaicked image is shown in Figure-10.

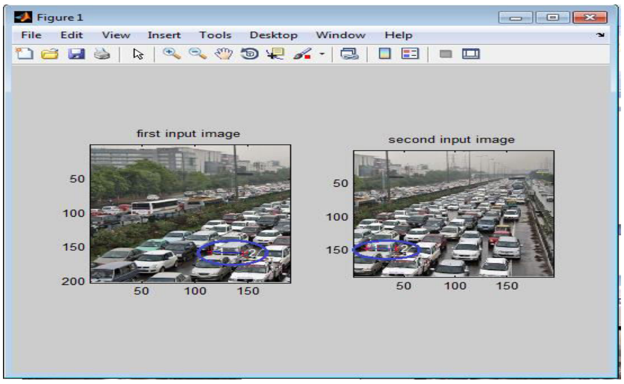

Figure-9. Two images captured at different projections.

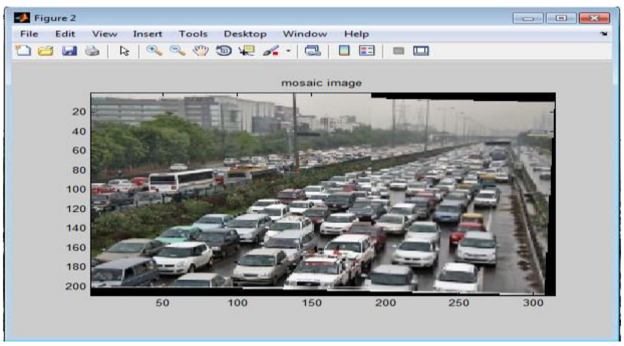

Figure-10. Final Mosaicked image.

Figure-11 shows the membership function of FES based on the input and output of inference system. To compare proposed technique with conventional techniques, a experiment has been performed on one vehicle. One of the vehicles is allowed to go to in W-E direction at 40Km/hr on AimSun test bed. Total time of 450 seconds is given to vehicle to check the covered distance. Randomly

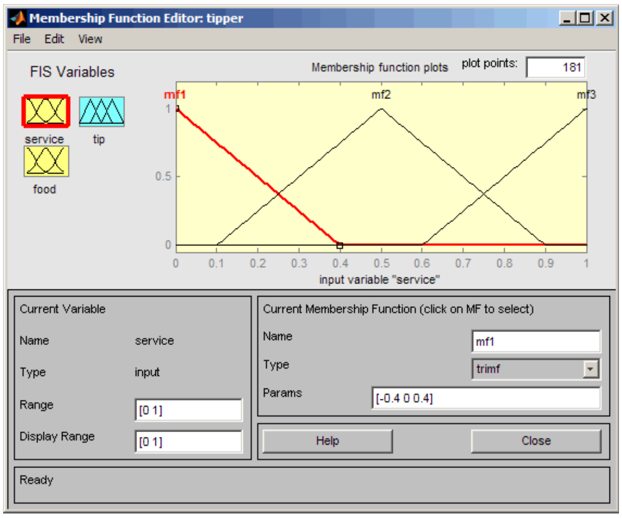

Figure-11. Membership function of FES.

traffic density is applied on road to check the performance. The same conditions have been applied to IDUCT, FES, ANN with conventional sensors techniques to check their performances. After simulate the experiment, it is found that vehicle when adopts fuzzy controller with vision sensor computing, covers 4.6m distance in specified time period whereas distance covered by vehicle using techniques IDUCT,FES and ANN is 4.3m, 4.0m and 3.7m, respectively.

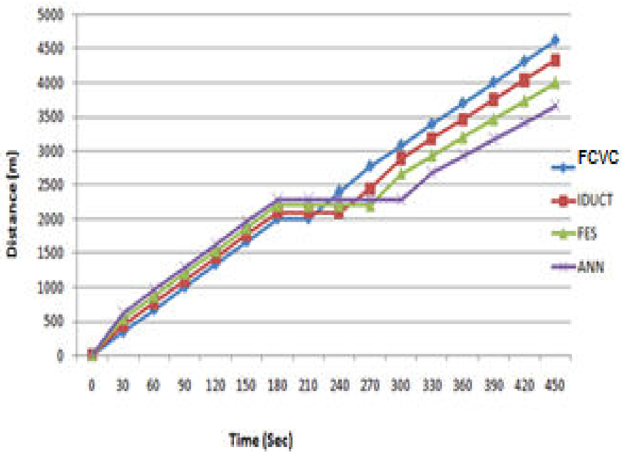

Figure-12. Comparison chart of conventional techniques with proposed scheme.

Simulation results shows average waiting time and moving times for vehicles. Whereas the time taken by vehicles when no distance is covered is the time when red light becomes on and remains on for a time depends upon traffic present on road and execution of algorithm. During this red light period decision making algorithm decides the timing of Green light for next cycle. As it can be seen in Figure-11 that knowledge based fuzzy controller with vision computing (FCVC) increases the average moving time and decreases the average waiting time.

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CONCLUSIONS

Road traffic congestion is a central problem in most developing regions. Most urban areas have poorly managed traffic networks with several traffic hot-spots or potential congestion areas. In this paper, we study the problem of road traffic congestion in high congestion hot-spots in developing regions. We first present a simple image processing algorithm to estimate traffic density at a hot-spot using web-camera feeds. Based on analysis of traffic images from live traffic feeds, we show evidence of congestion collapse which last for elongated time periods. Our hope is that localized de congestion mechanisms are potentially easier to deploy in real-world settings and can enhance the traffic flow at critical hot- spots in road traffic networks. We believe that this represents our initiative in development of low-cost deployable strategies for alleviating congestion in developing regions. Based on the accurate dynamic traffic density measurement on road, robust and dynamic knowledge based fuzzy controller technique with vision computing to manage the traffic lights has been developed for the purpose of maximizing traffic throughput and minimizing average waiting time at an intersection.

REFERENCES

[1] DaiY., Hum J., Zhao D., Zhu F. 2011. Neural network based online traffic signal controller design. IEEE international conference on Intelligent Transportation System. pp. 1045-1050.

[2] Wen W. 2008. A dynamic and automatic traffic light control expert system for solving the road congestion problem. Expert Systems with Applications. 34(4):2370-2381.

[3] Patel M., Ranganathan N. 2001. An Intelligent Decision-Making System for Urban Traffic Control. IEEE Transactions-Vehicular Technology. 50(3): 816-829.

[4] J. B. Sheu. 2006. A composite traffic flow modeling approach for incident-responsive network traffic assignment.Physica A. 367: 461-478.

[5] S. Y. Liu, L. Xia. 2001. Fabric image mosaic based on cellular automata. Journal of Textile Research. 1(32): 29-33.

[6] Y. J. Hou, J. Cao. 2010. An image mosaic method based on harris corner feature. Informatization Research. 10(36): 23-25.