September 10 - 12, 2007
Pilsen, Czech Republic

A PASSIVE OPTICAL LOCATION WITH LIMITED RANGE

ING. TOMÁŠ JIRKŮ
DOC. ING. PAVEL FIALA, PHD.
ING. PETR DREXLER

Abstract: *We know active and passive methods of a location. This article deals only with the passive location of dynamic targets (see [1]-[7]). The passive optics location is suitable just for the tracking of targets with mean velocity which is limited by the hardware basis. The aim of this work is to recognize plasma, particles etc. It is possible to propose such kind of evaluation methods which improve the capture probability markedly. The suggested method deals with the short-distance evaluation of targets. We suppose the application of three independent principles of how to recognize an object in a scanned picture. These principles use similar stochastic functions in order to evaluate an object location by means of simple mathematical operations. The methods are based on direct evaluation of picture sequence with the help of the histogram and frequency spectrum. We are trying to find out the probability of appearance of moving object in pictures. If the probability reaches a setting value, we will get a signal. The processing of dynamic pictures and their filtration represent a significant part of work [8]-[14]. Static objects, background (trees, buildings) must be filtered off before searching the objects. This filtration is also done by means of the probability function. The probability distribution of an object position is gained from a sequence of more pictures.*

1 OUTLINE

At the DTEEE FEEC in Brno we are engaged in experimental ascertaining of water properties, elements and their moving (slow and quick) in an electric field. One of problems is how to recognize identical elements, their clusters and objects in dynamic state. It is necessary to realize this observation through automatic or semiautomatic image recognition according to the lifetime or speed of these effects. Thus, it is possible to record the trajectories of demanded objects.

A concept of passive optical location with limited range was designed. The basis of this concept is an optical system which can locate and deliver (record) pictures with sufficient resolution o_s and sufficient rate o_r. For the first experiments, delivered components such as F-OS-226CA-PAL or TVP5150AM are used. The basic concept is shown in fig. 2. A significant problem is the scanned picture processing and quick evaluation - with probability $p_{f\,-}$ of whether the monitored object is the desired target object. More approaches are possible and they are described in sources [1]-[13]. The basic methods of image processing are described in source [14].

2 MATHEMATICAL MODEL

The main idea is based on three different methods of dynamic image analysis. The first one is the method of differential images, the second one is the histogram monitoring method and the last method is based on an analysis of image frequency and phase spectrum. These methods are bounded by probability functions.

The main goal of the experimental part of this work is the retrieval of an applicable probability function (Herodotus, Bernoulli, Bayes, Laplace, Jeffreys, Cox, Shannon) for the monitored target deliver recognition. The probability of a target delivering is given by:

$$p_f = p(A) \cdot p(B) \cdot p(C) \text{ in } \Omega, \quad (1)$$

where Ω is the monitored image area, p(A) is the monitored object move probability given by the first method, p(B) is the monitored object move probability given by the second method and p(C) is the probability given by the third one.

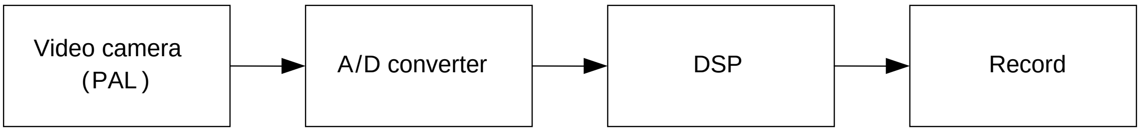

Fig. 2 Block diagram of a passive optical locator with limited range

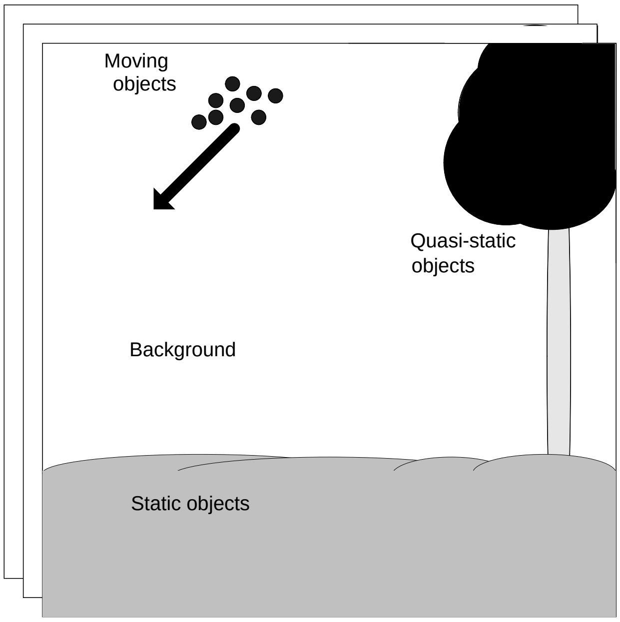

Fig. 1 Example of an image recorded by a passive optical system

The basic part of the differential images method model may be described the following way. We have u_0, X: $\Omega \to R$, with $\Omega \subset R^2$ then for the coeficients ω picewise smooth image approximation holds:

$$\omega_1 = \frac{u_{t+1}-u_t}{\Delta X_{t,t+1}}, \omega_2 = \frac{u_{t+2}-u_{t+1}}{\Delta X_{t+2,t+1}},\ u \cong \omega_1 X_t + \omega_2 X_{t+1} \text{ in } \Omega, \quad (2)$$

the probability of the monitored object delivering is

$$p(A) = \left(\left(u_{t+1}-u_t\right)/u_t\right)\cdot\left(\left(u_{t+1}-u_{t+1}\right)/u_{t+1}\right). \quad (3)$$

The method is completed with a method of segmentation [12]. The choice of an applicable number of segments choice makes the image processing time shorter. It is possible to describe the model as

$$\inf_{u,\Gamma}\left\{F(u,\Gamma) = \int_{\Omega}|u-u_0|^2 dx + k_1 \int_{\Omega-\Gamma}|\nabla u|^2 dx + k_2 \int_{\Gamma} d\Gamma\right\}, \quad (4)$$

where Γ is the border of area Ω, k_1, k_2 are weight function. We obtain the approximated function solution u in the desired segment if we find the minimum.

The histogram monitoring method [14] is based on the statistics image processing method; there, similarly as in the Monte-Carlo method, the evaluation of an image is done depending on the image color structure. We can describe this method. We have u_0, X: $\Omega \to R$, with $\Omega \subset R^2$ then for weight k_3

$$p(B) = k_3 \frac{u_{t+1}(X) - u_t(X)}{u_t(X)} \text{ in } \Omega, \quad (5)$$

The frequency and phase spectrum method is a variant close to the histogram monitoring method. The difference of this method is in using the continuous image information spectrum and the added information is in the phase spectrum space. This information can make the whole image processing more accurate. It is possible to describe the analysis model for u_0, X: $\Omega \to R$, with $\Omega \subset R^2$ from the Fourier transform:

$$U_F(m,n) = \sum_{X_1=0}^{M-1}\sum_{X_2=0}^{N-1} u_0(X_1, X_2) e^{-j\frac{2\pi m X_1}{M}} e^{-j\frac{2\pi m X_2}{N}} \quad (6)$$

where M, N are the information about the image, m, n are the counts of coefficients in the discrete series. Then the amplitude spektrum is given by

$$U_{AF}(m,n) = \left|U_F(m,n)\right| \quad (7)$$

and the phase spectrum

$$U_{\varphi F}(m,n)=\boldsymbol{arctan}\left(\frac{imag\left(U_F(m,n)\right)}{real\left(U_F(m,n)\right)}\right). \quad (8)$$

This approach is not suitable for fast image processing, because in this case each pixel is solved. A preferable image spectrum processing method uses the discrete cosine transform

$$U_c(m,n)=\sum_{X_1=0}^{M-1}\sum_{X_2=0}^{N-1}u_0(X_1,X_2)\cos\left(\frac{\pi(2X_1+1)m}{2M}\right)\cdot \cdot\cos\left(\frac{\pi(2X_2+1)n}{2N}\right) \quad (9)$$

The transformed image has similar properties as the amplitude spectrum of the Fourier transform for the low-frequency character of image, but it is processed in a faster way. The dependent dynamic object presence probability is with weight k_4

$$p(C)=k_4\frac{U_{t+1}(X)-U_t(X)}{U_t(X)} \text{ in } \Omega. \quad (10)$$

3 EXPERIMENTS AND CONCLUSION

The experiment was prepared on the basis of the fig.2 diagram. In fig. 3, the experimental connection of the optical locator with limited range basic parts is shown. Basic measurement and dynamic image analysis are performed on these components. Next, the device for the plasma element monitoring will be prepared, as mentioned above.

The locator system will be tested on bird moves. The real image is in fig. 4 and the image recorded by the video-camera is in fig.5.

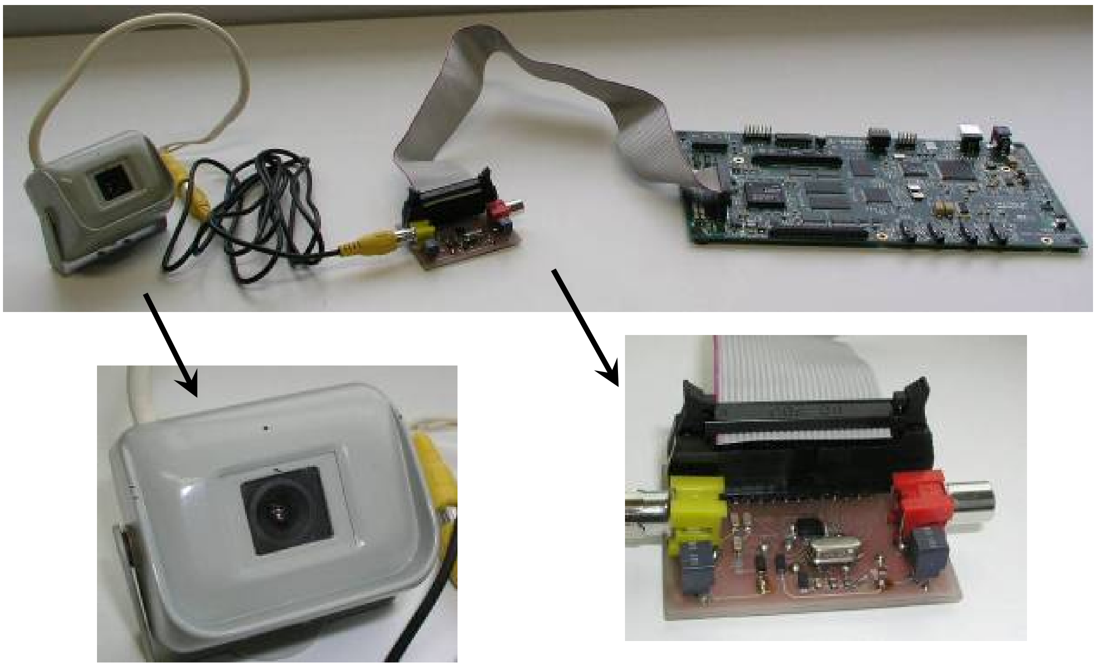

Fig. 3 Basic parts of the passive optical locator with limited range

Fig. 4 Example of an image scene

Fig. 5 Example of a recorded image scene, o_s =640x480 pixels

4 REFERENCES

[1] Herman, S. and Moulin, P. "A Particle Filtering Approach to FM-Band Passive Radar Tracking and Automatic Target Recognition," in Proceedings of IEEE Aerospace Conference, Boston, 2002.

[2] nternet source http://www.ifp.uiuc.edu/~smherman/darpa

[3] Ehrman, L. M. and A. D. Lanterman, "Automated Target Recognition Using Passive Radar and Coordinated Flight Models," in Proceedings of SPIE International Conference,Orlando, Florida, 2003.

[4] Lanterman, A. D. and D. C. Munson, "Deconvolution techniques for passive radar imaging," in Proceedings of SPIE International Conference,Orlando, Florida, 2002.

[5]Yong Wu and D. C. Munson, Jr., "Multistatic passive radar imaging using the smoothed pseudo Wigner-Ville distribution," in Proceedings of IEEE Image Processing Conference, 604-607, 2001.

[6]Lind F. D. and J. D. Sahr, "Passive Radar and the Low Frequency Array," in Proceedings of General Assembly of the Inetrnational Union of Radio Science, Maastricht, Netherlands, 2002.

[7]Neyt X., J. Raout, M. Kubica, V. Kubica, S. Roques, M. Acheroy and J. G. Verly, "Feasibility of STAP for passive GSM-based radar," in Proceedings of the IEEE Radar Conference*, Verona, NY, April, 546-551, 2006.*

[8]Töreyin B. U., A.E. Cetin, A. Aksaya, M.B. Akhan, "Moving object detection in wavelet compressed video," Signal Processing: Image Communication*, Vol.20, 225-264, 2005.*

[9]Morimoto C., D. DeMenthon, L. Davis and R. Chellappa, "Detection of Independently moving objects in passive video," in Proceedings of Intelligent Vehicles Symposium,Detroit, MI, 270-275, 1995.

[10]Nguyen H. T., M. Worring, and A. Dev, "Detection of moving objects in video using a robust motion similarity measure," IEEE Transactions on Image Processing*, Vol.9, 137-141, 2000.*

[11]Vese L.A., "Multiphase detection and image segmentation," UCLA C.A.M. Report 02-36, June 2002.

[12]Chang K, Handbook of optical components and engineering, Wiley-Interscience, New Jersey, 2003

[13] Gonzales C. G., R. E. Woods and S. L. Eddins, Digital image processing using Matlab, Pearson Prentice Hall, New Jersey, 2004

ACKNOWLEDGMENTS

The paper was prepared with the support of the research plans MSM 0021630516, GA102/07/0389, KJB208130603 and MSM0021630513.

Doc Ing. Pavel Fiala, Ph.D.
Brno University of Technology
Dept. of Theoretical and Experimental Electrical Engineering,
Kolejni 2906/4, 612 00 Brno, Czech Republic
E mail: fialap@feec.vutbr.cz

Ing. Tomáš Jirků.
Brno University of Technology
Dept. of Theoretical and Experimental Electrical Engineering,
Kolejni 2906/4, 612 00 Brno, Czech Republic
E mail: jirku@feec.vutbr.cz

Ing. Petr Drexler
Brno University of Technology
Dept. of Theoretical and Experimental Electrical Engineering,
Kolejni 2906/4, 612 00 Brno, Czech Republic
E mail: xdrexl00@stud.feec.vutbr.cz