A Decision Method for Recognition in Video and Infrared Multicameras System

CORNEL BARNA
Aurel Vlaicu University
Arad Romania
barnac@rdslink.ro

Abstract. - This article presents an information fusion based decision method for a recognition system composed by two video cameras and two infrared cameras. First, for each of video and infrared cameras systems, geometric characteristics are obtained which in a second stage are used in three types of information fusion. The decision, for determining the label of the object captured in the images is made using a soft type rule by considering the original algorithm based on a modified Hebb-law. Comparing this result with a hard method, it can be concluded that the performance of the presented soft method overtakes the hard one.

Key-Words: - Uncertainty, Information fusion, Video cameras, Infrared cameras, Soft and Hard decision

y

1. Introduction

The complexity of the captured images, and the numerous parameters that can influence the localization and recognition in images determined the appearance of numerous articles, which propose a vast number of methods [1],[2]. One issue of this subject is to improve the rate of correct recognition using information fusion. It was proposed numerous fusion methods, each having advantages in different situations. But in the end it must be made a decision to relate or not the unknown object with one prototype or cluster. For improving the correct labeling process it can be made a decision, not only on one information fusion result, but based on a set of information fusion, which can be adaptive. This means that the decision can be computed taking in relation different types of fusion, hopefully having different theoretically fundaments, and the importance of every fusion method on the result can be based on the past experience. Applying this point of view it can be obtained an adaptive algorithm

2. Information fusions

First, for each of video and infrared cameras systems, geometric characteristics are obtained which in a second stage are used in three types of information fusion. The methods for obtaining features from images are largely presented in numerous articles and is not one of our main purpose [3], so in experiments it were used only seven geometric characteristics for matching the unknown patterns with prototypes. The results are represented as a complementary of the ratio between the measured features and the prototypes, and were denoted as R_V for video cameras and respectively R_I for infrared cameras.

For the final decision process it were selected three type of information fusion based on experimental conclusion. It must be underlined that more different theoretical bases the fusion methods have, more independent results it resulting.

The first fusion is made using a heuristic method. This is obtained with the relation 1

$$\mu_E = a \cdot R_V + b \cdot R_D \quad (1)$$

where

a, b are constants which must satisfied the conditions $a+b=1$,$a, b \in [0, 1]$,

and

R_V, R_D represents the results provided by the video and the infrared cameras.). The performance of this information fusion depends largely on the selected constants values, which must be established from experiences.

The second fusion is obtained by using a fuzzy method [4]. For applying this method, first it must be obtained the membership values for the video cameras μ_V, and for infrared cameras μ_D. During 24 hours these values have time dependence, the video system being more reliable when light conditions are good, and the infrared system having a better recognition rate by night. It results the function presented in relation 2.

$$\mu_F = \frac{\mu_V \cdot R_V + \mu_D \cdot R_D}{\mu_V + \mu_D} \qquad (2)$$

where,

μ_V, μ_D are fuzzy memberships of the video and infrared cameras systems. It can be easily observed that the global uncertainty is improving the system performance, because in day condition the video information is dominant, having in the same time lower uncertainty, and in night condition the infrared information has a bigger influence on the result, when it's membership value is higher.

The last information fusion implied a reinforcement method between the results obtained from the two types of captors. Because the information obtain from the video cameras is more significant than the information from the infrared system, the latter will only reinforce the conclusion of the former. Thus, the result obtained from the infrared cameras increase or decreases the result obtained from the video cameras. The following relationship will be operated:

$$\mu^1 = \frac{1}{1+\alpha}\left(\mu_V + \alpha \frac{|R_V - R_D|}{|R_V|} \cdot \mu_D\right) \qquad (3)$$

and the information fusion result is:

$$\mu_C = \min(1, \mu^1) \qquad (4)$$

where:

$\alpha \in [0,1]$ is the weigh value which is changing in time depending of the influence of the external conditions.

3. Decision method

Finally a decision must be made in order to confirm or not the recognition of the object. This process can be made using a hard method like a vote type were each results from the information fusion methods has the same decision influence, or using a soft method were the information fusion results has an adaptive weigh influence, depending on the history of the correct results.

3.1. Hard decision

This method is based on majority type decision. First, the three information fusion results are convert to crisp numbers D_i by comparing the membership of this values μ_i ($i \in \{E, F, C\}$) to a threshold θ, (which is usually ½). The final decision is obtained using the relation 5.

$$D_H = \begin{cases} 1 \mid card(D_i = 1) \in \{2;3\} \\ 0 \mid card(D_i = 1) \in \{0;1\} \end{cases} \qquad (5)$$

where

D_H represents the hard type of decision. Thus, the decision is based on the three crisp information fusion results. If two or all three decisions are favorable for the passing of the result, the final result is accepted.

3.2. Soft decision

The soft decision is based on a reverse type of approach. First is made the decision, and only in the end is determined the crisp result. That means, the used of the weigh sum of the fusion results memberships, as is presented in relation 6.

$$D_S = \begin{cases} 1 \mid (a \cdot \mu_E + b \cdot \mu_F + c \cdot \mu_C \geq \theta \\ 0 \mid (a \cdot \mu_E + b \cdot \mu_F + c \cdot \mu_C < \theta \end{cases} \qquad (6)$$

where $a, b, c \in [0;1]$ are the weigh constants, and the following relation must be satisfied: $a+b+c=1$
Similar to the method used in hard decision, θ, is a threshold applied for obtaining the crisp number. Usually, is used a value = ½., which corresponds to the maximum uncertainty [6].

The weigh constants are obtained by an iterative method, by tuning these values using a learning process based on comparing the obtain result with the real situation. Other method for determining the constants can be based on Hebb type learning. This procedure applied in artificial neural networks, is based on the reinforcement of the most used constants.

It was used the following relation [5]:

$$\Delta w_{ij} = \varphi \cdot y_j \cdot x_i - \phi \cdot y_j \cdot w_{ij} \qquad (7)$$

where

x_i, y_j is the i input and respectively j output, w_{ij} is the weight of mutual connection, and φ, ϕ represents the learning and respectively the forgetting constant used in the learning process.

The new relation proposed in this article is:

$$\Delta coef_i^t = \varphi \cdot D_i - \phi \cdot \varepsilon_i \qquad (8)$$

where is the index of the heuristic, fuzzy or reinforcement fusion method

$$i \in \{E, F, C\}, \text{ and } coef_i^t = \begin{cases} a^t \mid i = E \\ b^t \mid i = F \\ c^t \mid i = C \end{cases}$$

The constants: *a,* b and *c* are obtained by updating at *t+1* period of time the previous constants used in moment *t*. Also it must be done a normalization operation in order to maintain the constants sum equal with one.

For obtaining the constant *a* using this new method it will be used the following relation

$$a = \frac{a^{t+1}}{a^{t+1} + b^{t+1} + c^{t+1}} \qquad (9)$$

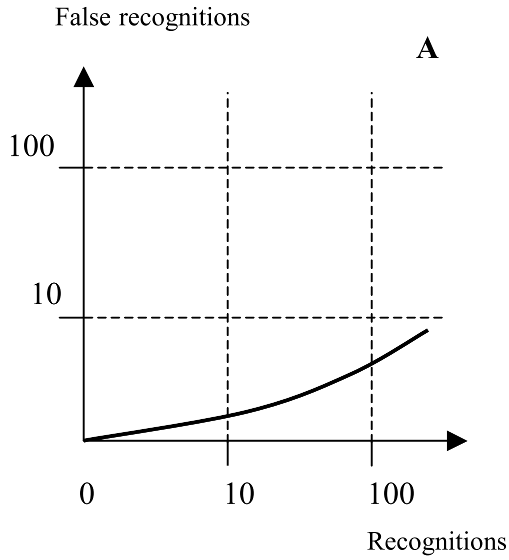
where

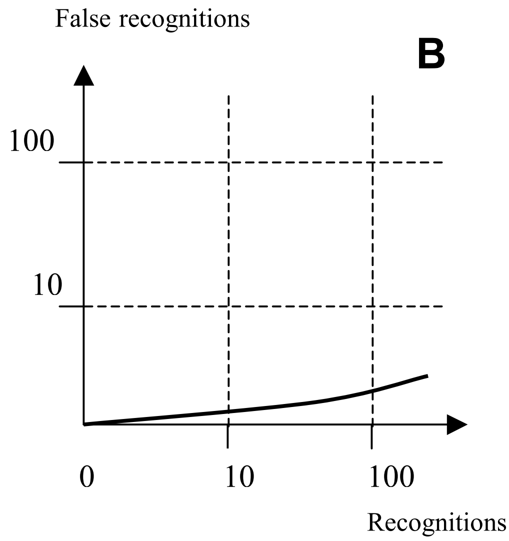
$$a^{t+1} = a + \Delta a^t \qquad (10)$$

Constants *b* şi *c* are obtained using the same relations. Similar with the original Hebb artificial neural network method the learning and the forgetting constants will take the following values φ =0,1, respectively ϕ=0,01,which had be proved to conduct to the best results in the testing process. It must be observed that even if in this article the two above mention constraints have kept the original names from the Hebb method, in this new relations, it have different meaning, adapted to the decision process. Thus, the φ constant is used to weight the right decision, increasing the influence of the specified fusion method. Similar, the ϕ constant is used to decrease the weight of the fusion method, reflecting the influence on the result of the errors.

4. Experiments

It was made a set of 100 experiments, in which were determined the three types of information fusions presented before. Two MDV213 type video cameras were used, and two TEM-412 type cameras with infrared projectors were used for obtaining the infrared images. For obtaining a 3D information, a triangulation process was performed. Seven sets of attributes were used. By extracting the area and the second order moment from the images the shape extraction was performed. The segmentation was made using the background extraction. The observations were made for 24 hours cycles.





The results are syntheses in diagrams presented in figure A, representing the hard decision and in figure .B. representing the soft decision. It can be easily observed that the soft method is more accurate. This conclusion was expected because the hard decision is making the decision to early and ignores a lot of information.

Also it was observed that, after a training period, the decisions based on multiple information fusion methods has performed at less equally good results with whose obtained applying any of the three fusion method used in computing. This observation can be easily explained, because the weighting constants outline the best performing information fusion method in the giving experimental conditions.

5. Conclusion

For recognition of an object obtained from camera images we have proposed a system composed by two video cameras and two infrared cameras. This system is used for computing three information fusion results, based on: a heuristic method, a fuzzy method and a reinforcement method, which were selected because having different theoretical bases. First, for each of video and infrared cameras systems, geometric characteristics are obtained which in a second stage are used in three types of information fusion.

As a first result of this article, based on the results obtains from these three fusion methods, is proved that the soft decision method is better performing that the hard decision method. Based on this conclusion it was taken in consideration a new soft decision method, by using a modified Hebb-law. This adaptation of an artificial neural network to a decision method has proved that by using a training based constants it can be improved the decision results. The results were expected because this type of method increases the influence of the better fitting fusion method, for various real conditions. But it must be underlined that this type of methods need time to adapt to external conditions. So, if the external conditions are changing fast and frequently the rate of misdetections and false recognitions can increase significantly.

References :

[1] F.Alkoot,J.Kittler: Modified product fusion, Pattern Recognition Letters Vol 23,Nr.8 2002

[2] A.Bargiera, W,Pedrycz, K.Hiroto Logic-based granular prototyping 26-th Annual International Computer Software COMPSAC 2002

[3] C.Barna An Alarm System Design with PIR using Fuzzy Sensor Fusion and Genetic Algoritm Program IEEE SOFA 2005 Szeged-Arad pag.195-199

[4] C.Barna, Information fusion method for outdoor alarm system INES2007 Inter.Conf. on Inteligent Engineering Systems Budapest pag.111-114

[5] M.Negnevitsky, Artificial Intelligence A guide to intelligent systems Ed. Addison-wesley London 2002

[6] R.Yager: A General approach to the Fusion of Imprecise Information, Inter'l Journal of Intelligent system Vol.12 1997