Seventh Int. Conf. on IFSs, Sofia, 23-24 August 2003
NIFS 9 (2003), 4, 129-134

INTUITIONISTIC FUZZY INTERPRETATION FOR PHOTOGRAPHIC RECORDS OF RELATIVELY UNPREDICTABLE EVENTS

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1. Introduction

The problem in general is photography of discrete objects of relatively small size (stars' powder particles, arc spots). The aim is to count the number of objects N using a sequence of frame photographic records.

Limitations of photographic methods are in that:
(i) N may be variable, N between frames is not recorded;
(ii) due to various reasons such as small size, irregular shape of objects and screening effects sometimes it is difficult to resolve two (or more) closely situated images of objects;
(iii) finite field of view leaves some objects out of it.

From the foregoing the number of objects recorded, k, seems to be equal to or less than the actual number of objects N.

The case of arc spots [1] is of extreme difficulty. These are highly luminous, fast moving, microscopic objects on the electrode surface that provide continuation of electric current between arc and electrode. Their imaging requires exposure times of the order of or less than 1 μs. Some electrode configurations restrict the field and/or angle of view as in the case considered here.

In the present communication we shall discuss the possibility to apply the formalism of intuitionistic fuzzy estimations (see [2]) for evaluation of the actual number of spots N. All notations related to intuitionistic fuzzienss are from [2].

2. Case study: ring of arc cathode spots

Vacuum arcs with expanding ring of cathode spots have been recorded (Fig. 1) using end-on frame photography of the cathode surface [3]. A sequence of shots were taken at times $t_1, t_2, t_3, ...$ such that $t_1 < t_2 < t_3 < ...$. Arcs between separating electrodes require side-on photography so that the record consists of object images along a line (Fig. 2) [4].

The arc initiation point is within the field of view. The arc developes in two phases, phase 1 with the ring still in the Field of View (FV) (see Fig. 3) and, if arc duration is sufficient, phase 2 with some spots outside FV (Fig. 4).

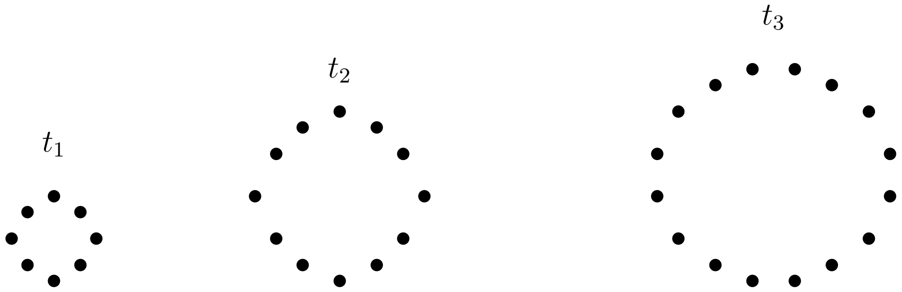

Fig. 1. The expanding ring of objects (cathode spots)

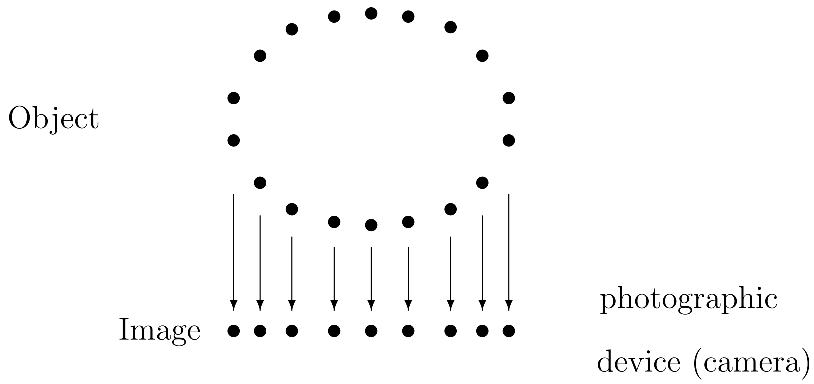

Fig. 2. Side-on observation

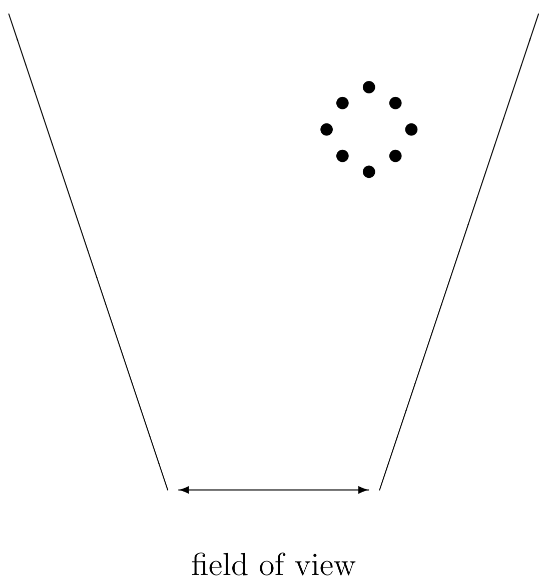

Fig. 3. Early stages of evolution of the ring

In a first attempt of interpretation we assume $N = constant$.

For the case from Fig. 3 we can define

$$\mu = 1 \text{ and } \nu = 0.$$

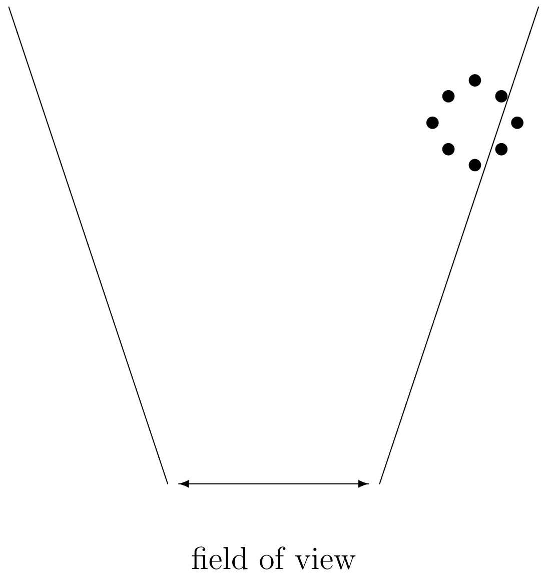

Fig. 4. Later stages of ring evolution

For the case from Fig. 4 we can define

$$\mu = \frac{\text{number of spots that are in FV}}{\text{total number of spots}},$$

$$\nu = \frac{\text{number of spots that are outside FV}}{\text{total number of}}.$$

$$\pi = 1 - \mu - \nu = 0.$$

For the example on Fig. 4:

$$\mu = \frac{3}{4} \text{ and } \nu = \frac{1}{4}.$$

Two reasons for screening of some spots are notable

(A) variation of azimuthal position of ring from shot to shot

(B) nonuniform distribution of spots in the ring.

A situation when all spots are in FV but unevenly distributed along the ring (Fig. 5) is considered next. Apart from spots that are seen as “single”, there are “enlarged spots” obserevd in the image that are due to spots screening each other.

We define

$$\mu = \frac{\text{number of observed spots}}{\text{total number of spots}},$$

$$\pi = \frac{\text{number of screened spots}}{\text{total number of spots}},$$

$$\nu = 1 - \mu - \pi = 0.$$

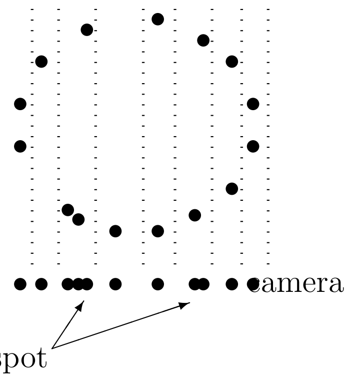

Fig. 5.

For the example on Fig. 5

$$\mu = \frac{8}{15} \text{ and } \pi = \frac{7}{15}.$$

Two sources of intuitionistic fuzziness are included in our final interpretation:
(i) spot before screens spot behind
(ii) spot(s) out of view.

For this case we define

$$\mu = \frac{\text{number of observed spots}}{\text{total number of spots}},$$

$$\pi = \frac{\text{number of all spots that are in FV and are screened}}{\text{total number of spots}},$$

$$\nu = 1 - \mu - \pi,$$

because

$$\begin{gathered}\text{total number of spots}\\ = \text{number of observed spots}\\ +(\text{number of all spots that are in FV} - \text{number of observed spots})\\ +\text{number of spots that are outside FV.}\end{gathered}$$

In the example of Fig. 6 there are 10 spots: 6 in FV and 4 - outside FV. In the image two of them coincide, while two other generate an enlarged spot. Therefore, the intuitionistic fuzzy estimations are the following:

$$\mu = \frac{4}{10} = \frac{2}{5},$$

$$\nu = \frac{4}{10} = \frac{2}{5},$$

$$\pi = \frac{8-4-2}{10} = \frac{1}{5}.$$

We must note that the center × of the configuration is within the field of view.

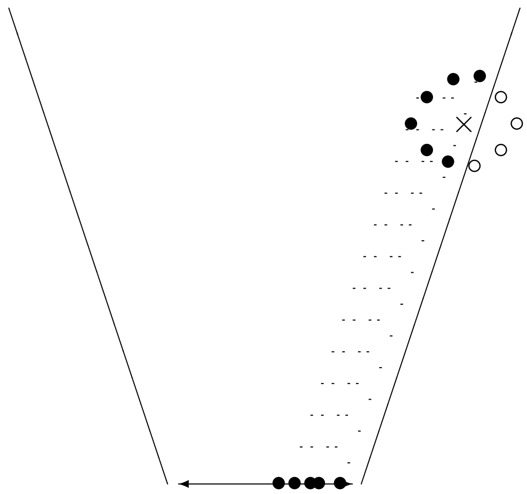

Fig. 6.

3. Conclusion

We have considered several situations of photographic records of objects that are made with the purpose to count the objects. It is seen that losses in the number of visible objects caused by different reasons can be accomodated within the framework of an intuitionistic fuzzy interpretation. Two extensions of the present study are envisaged
(i) analysis of situations with variable number of objects by superposition of an intuitionistic fuzzy set on an intuitionistic fuzzy set (see [2]);
(ii) the possibility to reduce the uncertainty in counting the objects by use of two or more cameras that "see" the objects from a different angle of view.

References

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